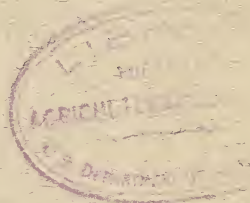


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UNITED STATES DEPARTMENT OF AGRICULTURE

REPORT ON
THE AGRICULTURAL EXPERIMENT
STATIONS, 1929



PREPARED BY THE
OFFICE OF EXPERIMENT STATIONS

OFFICE OF EXPERIMENT STATIONS

W. H. EVANS, Acting Chief

RELATIONS WITH THE STATE EXPERIMENT STATIONS

W. H. EVANS, W. H. BEAL, G. HAINES, J. I. SCHULTE, SYBIL L. SMITH, R. W. TRULLINGER,
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EXPERIMENT STATION RECORD

Editor: HOWARD LAWTON KNIGHT

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Meteorology—W. H. BEAL.
Soils and Fertilizers—H. C. WATERMAN.
Agricultural Botany and Diseases of Plants—W. H. EVANS and W. E. BOYD.
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UNITED STATES DEPARTMENT OF AGRICULTURE
OFFICE OF EXPERIMENT STATIONS

Washington, D. C.

October, 1930

REPORT ON THE AGRICULTURAL EXPERIMENT STATIONS, 1929

By W. H. BEAL and H. M. STEECE¹

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INTRODUCTION

The agricultural experiment stations made substantial progress during the year, as shown especially by increased income, improved personnel and facilities for research, and expanded and more productive lines of work. The stations, while still giving primary attention to local needs and problems, continued to develop a national viewpoint and broader policies. Progress was for the most part along familiar and well-established lines, having to do especially with production, but there was also notable progress in research in the less developed fields of agricultural economics and home economics, which deal particularly with mar-

keting and utilization of farm products and rural living.

FINANCIAL SUPPORT

The total revenues of the experiment stations in 1929 exceeded those of the preceding year. This was due mainly to the increases in the Purnell fund, the sales receipts, and the State appropriations, but the income from every source except the appropriations under the Hatch and Adams Acts was greater than the year before. State support of the stations was more than maintained as compared with the past year, and the receipts from sales were notably larger.

The income of the stations from different sources in 1928 and 1929 is shown in Table 1.

¹ With the collaboration of other members of the office staff.

TABLE 1.—Comparison of the revenues of the agricultural experiment stations for the fiscal years ended June 30, 1928 and 1929

Sources of income	1928	1929
Hatch Act.....	\$720,000.00	\$720,000.00
Adams Act.....	720,000.00	720,000.00
Purnell Act.....	1,920,000.00	2,400,000.00
Appropriations for insular stations.....	237,640.00	246,400.00
State appropriations and allotments.....	8,054,679.51	8,120,801.08
Fees.....	569,348.92	613,554.88
Sales receipts.....	1,810,764.78	1,996,470.40
Miscellaneous income.....	414,961.83	417,917.78
Balance from previous year.....	593,018.02	1,172,908.07
Total.....	15,040,413.06	16,408,052.21
Increase 1929 over 1928.....		1,367,639.15

The funds available to the stations in 1929, amounting to \$16,408,052, included \$4,086,400 from Federal appropriations and \$12,321,652 from sources within the States. The Federal appropriations reached \$80,000 for each State—\$15,000 each under the Hatch and Adams Acts and \$50,000 under the Purnell Act. The increase of \$10,000 for each State under the Purnell Act made a total increase of \$480,000 under the Federal acts. The financial support of the experiment stations in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands, provided for in the appropriation acts of the Department of Agriculture, amounted to \$246,400—\$8,760 more than in 1928.

Over three-fourths of the funds available to the stations in 1929 were derived from other than Federal sources. The income of \$12,321,652 from State sources—State appropriations, sales receipts, and miscellaneous revenues, including balances from the previous year—represented an increase of \$878,879 over the amount derived from these sources the year before. The relative rank of the stations on the basis of total income was about the same as in the preceding year. The same 5 stations, viz, California, Illinois, Indiana, Ohio, and Texas, received more than \$500,000 as supplementary funds, but 18 instead of 14 stations reported supplementary funds ranging from \$200,000 to \$500,000. The past year was the first in which all stations received over \$10,000 as supplementary funds, but in the case of at least 3 stations these funds were used mainly for fertilizer and other control work and were of little if any benefit to the research programs of the stations concerned.

The supplementary funds of the stations for the past two fiscal years are compared in Table 2.

TABLE 2.—Income of the agricultural experiment stations from within the States for the years ended June 30, 1928 and 1929

Station	1928	1929
Alabama.....	\$87,953.55	\$235,781.75
Arizona.....	129,325.79	111,871.42
Arkansas.....	92,632.32	205,326.62
California.....	785,722.73	837,135.55
Colorado.....	174,132.04	190,025.01
Connecticut State.....	210,640.02	214,437.50
Connecticut Storrs.....	60,640.61	57,272.93
Delaware.....	37,780.52	38,905.44
Florida.....	338,564.43	355,845.99
Georgia.....	63,152.87	66,953.10
Idaho.....	57,321.93	48,823.09
Illinois.....	524,317.17	531,169.40
Indiana.....	650,965.12	756,348.85
Iowa.....	283,983.95	287,699.09
Kansas.....	198,085.64	205,379.17
Kentucky.....	327,615.58	361,214.88
Louisiana.....	143,924.51	150,573.04
Maine.....	66,429.51	69,086.58
Maryland.....	123,247.05	141,554.38
Massachusetts.....	229,632.19	247,784.46
Michigan.....	346,584.83	333,414.27
Minnesota.....	451,751.08	414,498.58
Mississippi.....	189,357.88	265,451.60
Missouri.....	178,698.84	194,109.07
Montana.....	154,399.36	156,578.14
Nebraska.....	251,637.29	223,912.27
Nevada.....	9,119.77	10,066.61
New Hampshire.....	34,207.12	39,965.23
New Jersey.....	357,152.68	419,664.06
New Mexico.....	36,796.33	35,129.11
New York Cornell.....	295,929.38	349,208.97
New York State.....	313,606.63	341,868.91
North Carolina.....	187,122.09	198,663.18
North Dakota.....	459,567.21	259,351.55
Ohio.....	1,233,172.82	1,472,532.76
Oklahoma.....	64,090.79	63,354.85
Oregon.....	251,270.81	337,697.55
Pennsylvania.....	116,465.19	154,122.11
Rhode Island.....	6,367.84	16,169.28
South Carolina.....	141,621.75	157,104.06
South Dakota.....	65,757.79	61,746.91
Tennessee.....	57,374.27	65,328.22
Texas.....	600,127.52	589,061.03
Utah.....	89,345.69	78,998.00
Vermont.....	20,566.90	21,088.54
Virginia.....	111,655.37	100,218.59
Washington.....	199,165.32	190,463.01
West Virginia.....	151,850.06	149,940.77
Wisconsin.....	416,978.08	426,592.36
Wyoming.....	64,964.84	82,163.77
Total State support.....	11,442,773.06	12,321,652.21
Federal funds.....	3,360,000.00	3,840,000.00
Grand total.....	14,802,773.06	16,161,652.21

Of the total supplementary funds available the past year, \$8,831,357—an increase of \$460,918 over the preceding year—was reported as used for research and experiments, and of this amount \$2,198,549 was expended for this purpose at the substations and other points.

A study of the distribution of experiment-station expenditures shows that of the Federal funds over 72 per cent was used for salaries and more than 10 per cent for labor. Over 88 per cent of the Adams fund was expended for salaries and labor, and about 5 per cent was allotted to chemical supplies and scientific equipment, so that 93 per cent of the fund was used for these 4 items. Of the Hatch fund, 88 per cent was used for salaries, labor, publications, and feeding stuffs, and of the Purnell fund, nearly 90 per cent was expended for salaries, labor, travel, scientific equipment, feeding stuffs, and publications, the amounts decreasing in the order named. While the distribution of expenditures from supplementary funds showed some general similarity to that of expenditures from the Federal funds, there were certain distinctions worthy of note.

The Federal funds represent annual congressional appropriations, and since, according to law, no annual appropriation extends beyond the fiscal year for which it is made, all unexpended balances revert at the close of the fiscal period concerned. It is to the advantage of the stations, therefore, to use the entire amounts of the Federal funds during the fiscal year for which they are appropriated. It is quite natural to find the supplementary funds carrying over balances to the succeeding year. During the three years 1927-1929 the balances carried over from one year to the next represented on the average nearly 10 per cent of the total of the supplementary funds. As in the case of the Federal funds, the largest charge against the supplementary funds was for salaries, but this amounted to only about 37 per cent, while the total labor charges were higher in proportion, reaching nearly 18 per cent. Next in amount of expenditure were those for buildings and land, over 6 per cent; those for feeding stuffs, more than 5 per cent; and those for traveling expenses, about 3.5 per cent. These five items, with the balances carried over, represented approximately 80 per cent of the funds available to the stations

from State appropriations, fees, sales, and miscellaneous sources.

A detailed statement of income and expenditures of the stations will be found on pages 92-100.

J. I. SCHULTE.

FACILITIES FOR RESEARCH

The improvements in facilities for research continued to keep pace with the increase in income of the stations and thus made possible the more efficient use of the funds available for research. The amounts spent for additions to the station buildings and other equipment during the year ended June 30, 1929, were as follows: For buildings, \$916,421; for library, \$67,939; for apparatus, \$196,931; for farm implements, \$236,245; for livestock, \$184,483; and for miscellaneous, \$461,863; a total of \$2,063,882.

Some of the additions to the buildings, land, and other equipment of the stations are noted in the following pages.

BUILDINGS

The construction and equipment of new buildings during the year provided improved facilities for many lines of work at the main or central stations as well as at the substations.

Among the larger buildings constructed or provided for was a new wing to the main building of the Citrus Experiment Station at Riverside, Calif., to cost \$125,000. A new animal husbandry and dairy building at the Alabama college, erected at a cost of \$131,000, furnishes improved facilities for the work of the experiment station. The University of Kentucky began the construction of a new dairy building to cost about \$150,000, which will be used in part by the experiment station. The Mississippi station practically completed a station administration building to cost \$160,000.

Cornell University had under construction a new plant industry building to cost over \$1,000,000, which will house some of the station work. The New York State station received a State appropriation of \$15,000 toward the construction of a horticultural building. Washington State College completed a new home economics building, which furnishes needed accommodation for research in this subject. An animal husbandry research building was in course of erection at the Louisiana station. The New Mexico station completed a new dairy labora-

tory at a cost of \$15,000. The Legislature of New Mexico made available to the college \$200,000 for building purposes to include the erection of an agronomy and a biology building, which will be used, to some extent, for station purposes.

The Michigan station, with a State appropriation of \$50,000, had under construction a poultry plant including two laying houses arranged and equipped especially for experimental work, and also a 3-story laboratory building planned and equipped solely for research. At the Ohio station a poultry building was completed at a cost of \$31,000, a poultry laying house was provided, and an entomology building to cost \$32,000 was planned. The New Hampshire station also added new poultry buildings and equipment.

Barns and similar farm buildings were put up or provided for at a number of stations. The Alabama station planned the erection of a new dairy barn to cost about \$18,000. The Washington station completed, at a cost of \$20,000, a new dairy barn. The West Virginia station completed a new sheep barn costing about \$6,600. The Oregon station built a new sheep barn and was authorized to build a new veterinary barn for experimental work with dairy cattle. The Florida station restored the buildings and otherwise repaired the damage to the Everglades substation at Belle Glade caused by the storm of September, 1928. The South Carolina station constructed at the Sand Hill substation an office and laboratory building, a superintendent's residence, and two 5-room cottages in preparation for more extensive work, largely in co-operation with the Department of Agriculture.

EQUIPMENT

There were many improvements in special equipment.

The California station erected three greenhouses at Davis at a cost of \$22,500, thus making available five modern structures of this type for experimental work. The Kansas station was granted \$6,000 for remodeling its greenhouse facilities. The North Carolina station provided additional greenhouse equipment for experimental purposes. The Nebraska station built, at a cost of about \$28,000, a series of greenhouses especially adapted to temperature control. New greenhouses were provided also by the New Hampshire station for work in agronomy.

The Tennessee station completed a greenhouse designed for use in its work in plant pathology. A greenhouse for study of plant diseases was completed at the Washington station.

Many improvements in equipment and facilities for work in agronomy were reported. A lysimeter, including 102 tanks, for the study of the leaching of nitrogen from soils and other soil problems, was installed by the Connecticut State station at the Tobacco substation at Windsor at a cost of \$3,000. A new type of lysimeter was installed at the New Jersey stations for the study of the drainage and leaching of different soil horizons without disturbing the soil profile. The West Virginia station constructed a series of soil bins for controlled experiments in agronomy.

The Illinois station devised an electrical seed-corn germinator with controlled temperature and humidity, which is useful not only in testing for germination but also for disease infection. The Kansas station installed at the Fort Hays substation a battery of experimental grain-drying bins and tanks for investigations on the curing and marketing of grain. The Michigan station built a machine for washing sugar beets and other similar roots, to determine with greater accuracy the net yields of plats, more especially in breeding work. The machine appears to be of value also for washing all kinds of roots and vegetables for market. This station also developed a device for laying mulch paper, which is of simple construction, and, while mainly of value in general cultural operations, is also of use in experimental work. The Ohio station developed a photometric method, using the selenium cell, for measuring the area of corn leaves. This station also evolved an apparatus for the study of plant growth under controlled conditions. The Missouri station added special apparatus and improved equipment for use largely in genetic studies with field crops.

The California station began construction at Riverside of a new insectary to cost about \$25,000. A new insectary and apiary was added to the equipment of the North Dakota station.

The California station completed and occupied at San Jose a well-equipped plant pathology laboratory erected at a cost of approximately \$8,000. At the North Carolina station a poultry-disease plant was completed and put into use especially for the

study of soil pollution and transmission of bacillary white diarrhea. The Nebraska station also completed and occupied a building for the study and control of poultry diseases by sanitary methods. The Legislature of Utah gave the station \$10,000 for a laboratory building for work on animal diseases and also made a special appropriation for such work.

Improvements in equipment for both scientific and practical work in horticulture were reported by a number of stations. The Iowa station set up apparatus for the determination of carbon dioxide as a measure of respiration in apples, tomatoes, and cut flowers in storage. The New Jersey stations developed a device for determining the texture of peaches with reference to shipping and edible quality. Similar tests were reported by the California station for establishing maturity standards for Bartlett pears for shipment to eastern markets and by the Oregon station for ascertaining the degree of maturity in prunes and the best time of picking them for shipment in fresh condition. In connection with studies on the standardization of dried prunes, the Oregon station perfected a gravity method of grading, based on floating in salt and sugar solutions of different specific gravities, which gives results closely agreeing with market standards of quality in both fresh fruit and the dried product. The West Virginia station reported the construction of an apparatus for growing plants in soil under microbiologically controlled conditions.

The Missouri station devised a tabulating machine which is considered especially adaptable to statistical computations of various kinds.

LAND

The land area devoted to experiment station uses was increased during the year. The Alabama station established a substation at Crossville to deal mainly with crops and poultry and one at Headland to study crops and hogs. The land for these substations was donated by the respective communities. Similarly, 160 acres was donated by Tensas Parish, La., for a new substation at St. Joseph. The Massachusetts station was given a special appropriation of \$800 for additional land for the cranberry substation at Wareham. Additions were made during the year to the farm of the Mississippi station, which now in-

cludes about 1,400 acres. The Nebraska station was authorized by the State legislature to dispose of a tract of land purchased some time ago for an irrigation school and to use the proceeds for additional lands and improvements at the Scottsbluff substation. Two farms recently purchased for the Oklahoma station were assigned to the animal husbandry department of the station, which will develop one for work with hogs and the other for work with cattle and the production of feed. The Oregon college secured a farm of 244 acres for use largely by the experiment station. The South Dakota Legislature authorized the purchase of 80 acres of land for the station.

The Rhode Island station acquired a 40-acre farm early in the year on which the research in poultry pathology and horticulture is to be located. An animal-disease laboratory was under construction and a farmhouse was reconstructed for station purposes. By an act of Congress approved February 16, 1929, the Secretary of the Interior was authorized and directed to exchange 18 sections of public lands in Utah for an equal value of Utah State lands of the same character for use in experimental sheep raising, the experiments to be conducted by persons designated by the director of the Utah station and in cooperation with the station.

J. I. SCHULTE.

PERSONNEL CHANGES

Changes in directorships during the year ended June 30, 1929, numbered 8. The number of other major changes in personnel was 111, as compared with 68 for the previous year. Of this number 51 were in the rank of chief, or heads of departments, and 60 were among the associates. There were 10 losses by death, and a number of changes were caused by either retirement or the relinquishment of administrative duties to devote time exclusively to research or teaching.

CHANGES IN DIRECTORSHIPS

E. D. Ball was appointed director of the Arizona station, effective October, 1928, succeeding J. J. Thornber, who relinquished the directorship to devote his time exclusively to research.

J. H. Skinner succeeded G. I. Christie as director of the Indiana station, holding this position in addition to his duties as dean of the school of

agriculture and director of agricultural extension at Purdue University.

The vacancy at the Louisiana station was filled by the appointment of C. T. Dowell, formerly director of the Oklahoma station.

U. P. Hedrick, vice director of the New York State experiment station, was made director of the station effective October, 1928, succeeding F. B. Morrison, who relinquished administrative duties to become head of the animal husbandry department at the New York State College of Agriculture.

At the New York Cornell station A. R. Mann, dean of the college of agriculture, assumed the duties of station director, which had been held by F. B. Morrison.

C. P. Blackwell was appointed director of the Oklahoma station, effective December 13, 1928.

B. E. Gilbert, chemist of the Rhode Island station, who had been acting director since the resignation of B. L. Hartwell, was elected director of the station, effective in February, 1929.

P. V. Cardon, farm economist, was made director of the Utah station vice William Peterson, who continues as director of the agricultural extension division. This change was effective July 1, 1928.

OTHER CHANGES

New appointments at the Alabama station included those of J. L. Seal, associate in plant pathology, and S. J. Schilling in animal nutrition research.

T. F. Buehrer, of the faculty of the University of Arizona, was added to the station staff as physical chemist.

C. O. Brannen was made assistant director of research at the Arkansas station retaining his duties as head of the department of agricultural economics. Madge E. Johnson, home economics research worker, resigned.

C. B. Hutchison was appointed director of the Giannini Foundation of Agricultural Economics, and associate director of research at the California station, assuming these duties in the fall of 1928. H. J. Webber, director of the Citrus Experiment Station, resigned his administrative duties, June 30, 1929, to devote his time exclusively to research on citrus stocks. L. D. Batchelor, horticulturist at Riverside, succeeded as director of the citrus work. D. R. Porter of Iowa was appointed associate plant breeder to fill the vacancy caused by the death of J. T. Rosa, which occurred August

7, 1928. Max Kleiber, of Zurich, Switzerland, was appointed associate in animal husbandry, and L. W. Taylor, associate in poultry husbandry.

G. S. Klemmedson was appointed associate in agricultural economics at the Colorado station. Resignations in the rank of associate included those of R. A. McGinty in horticulture, C. N. Shepardson in animal husbandry, and Mrs. Marjorie J. Peterson, investigator in home economics. Robert Gardner succeeded J. C. Ward as soil chemist at the Rocky Ford substation.

Walter Landauer, associate in animal genetics at the Connecticut Storrs station, succeeded L. C. Dunn as head of the department. J. F. Markey was appointed associate sociologist at this station. E. W. Sinnott, plant geneticist, and J. G. McAlpine, bacteriologist in poultry diseases, resigned.

T. B. Osborne, chief of the biochemistry division of the Connecticut State station, died January 29, 1929. His associate, H. B. Vickery, was appointed as biochemist in charge.

The Delaware station reported the resignation of C. L. Benner, chief in agricultural economics, effective June 30, 1929.

The veterinary work at the Florida station was transferred to the division of animal husbandry, and A. L. Shealy, the veterinarian, was made head of the department. W. B. Tisdale, plant pathologist at the Tobacco station, was transferred to the main station as head of the plant pathology work, the position having been vacant since the death of O. F. Burger in January, 1928. R. B. Becker, of Oklahoma, was appointed associate in dairy husbandry. A. F. Camp, associate horticulturist, was promoted to the rank of horticulturist; R. M. Barnette and R. L. Miller, assistants, were promoted to associate in soil chemistry and associate in entomology, respectively. S. T. Fleming, for several years assistant to the station director, was made assistant director of the station.

Leah Ascham was appointed nutrition specialist at the Georgia station, cooperating with the Georgia State College of Agriculture. R. C. Campbell, cotton fiber specialist, resigned October 23, 1928, and was succeeded by G. A. Hale, assistant agronomist. R. C. Thomas, plant pathologist at the Georgia Coastal Plain station, died December 25, 1928.

C. W. Hungerford, plant pathologist at the Idaho station, was made also vice director of the station. E. M.

Gildow, of New Hampshire, was appointed veterinarian, and J. D. Remsberg, jr., was made field agronomist and seed commissioner, succeeding C. B. Ahlson. P. A. Eke, of the West Virginia station, was appointed agricultural economist, effective May 1, 1929. R. E. Neidig, the station chemist, resigned in December, 1928, and H. P. Magnuson, an assistant, was named as acting chemist.

At the Illinois station R. C. Ashby was made associate chief in livestock marketing, by promotion from the rank of assistant chief. Resignations in the rank of associate included those of F. L. Winter in plant breeding, A. L. Lang in soil experiments, E. A. Tunnick in animal pathology, and H. A. Berg in farm organization and management.

F. G. King, associate chief of the department of animal husbandry at the Indiana station, was made head of the department, effective October 1, 1928. M. W. Gardner was appointed acting head of the department of botany, following the resignation of H. S. Jackson. R. A. Whiting, associate animal pathologist, resigned September 10, 1928, and G. N. Hoffer, associate botanist and plant pathologist, February 1, 1929. L. S. Robertson was transferred from the extension service to the station staff as associate in farm marketing. Claude Harper and J. H. Hilton, of the extension and teaching faculties, were added to the station staff, the former as associate in animal husbandry and the latter as associate in dairy production. G. H. Roberts, associate in veterinary science at the station for the past 10 years, died January 3, 1929.

A. G. Black, of Minnesota, succeeded C. L. Holmes as chief of the agricultural economics section at the Iowa station. E. C. Volz, of the college staff, was made chief in floriculture at the station, and H. A. Sayre was placed in charge of the work in household equipment. C. H. Richardson was appointed assistant chief in entomology, and E. W. Bird, of the teaching staff, succeeded L. T. Anderegg as assistant chief in dairy industry. H. A. Bittenbender, chief in poultry husbandry, resigned. L. H. Pammel, head of the department of botany, resigned his administrative duties, continuing in research.

The department of agricultural engineering of the Kansas college was made a part of the station, and F. C. Fenton, head of the department, with

R. H. Driftmier and C. A. Logan, investigators, were added to the staff. C. H. Whitnah was appointed dairy chemist. Resignations in the rank of associate included those of R. W. Titus, in feeding-stuffs analysis; E. S. Lyons, in soils, and F. H. Collins, in food chemistry.

H. B. Price of Minnesota was appointed head of the department of markets and rural finance at the Kentucky station, succeeding O. B. Jessness, resigned. In addition to his work as plant pathologist, W. D. Valteau was made head of the department of horticulture. Statie Erikson, professor of home economics, succeeded Mariel Hopkins as head of the department. W. A. Price was appointed head of the department of entomology and botany, vice Harrison Garman, retired. A. M. Peter, the station chemist, also retired, effective June 30, 1929.

C. W. Upp was appointed head of the poultry department at the Louisiana station, and J. P. Gray was made agronomist, vice D. N. Barrow, who died December 20, 1928. Gertrude Sunderlin was appointed research specialist in home economics. R. L. Mayhew of the university was added to the station staff for work in parasitology, and R. L. Thompson and W. M. Stevens for work in agricultural economics. C. B. Haddon, a former district extension agent, was made superintendent of the newly established cotton branch station in Tensas Parish.

The Maine station reported the appointment of Fred Griffec, of Oklahoma, as biologist, effective August 1, 1928. Reiner Bonde in plant pathology and J. L. Babson, jr., in agricultural economics were promoted to the rank of associate.

R. P. Thomas was added to the Maryland station staff as associate in soil technology. L. W. Erdman, in soils, and V. R. Boswell, oleiculturist, resigned in the fall of 1928.

E. L. Anthony, of West Virginia, succeeded O. E. Reed as head of the dairy department at the Michigan station, effective September 1, 1928, and C. S. Robinson was elected head of the chemical section to succeed A. J. Patten, resigned. C. E. Millar, of the teaching staff, was added to the station as research associate in soils. E. B. Hill, assistant to the director of the station, was placed in charge of the newly established department of farm management.

H. K. Hayes, plant breeder at the Minnesota station, was made chief of

the reorganized division of agronomy and plant genetics, and O. B. Jesness, formerly of the Kentucky station, was appointed chief of the division of farm management and agricultural economics. Andrew Boss relinquished his research in farm management to devote his time entirely to his administrative duties as vice director of the station. Francis Jager, head of the beekeeping division, resigned October 1, 1928, and the division was combined with that of entomology and economic zoology, M. C. Tanquary being appointed station apiculturist. L. M. Winters, of the University of Saskatchewan, was appointed animal breeder. E. A. Stewart, associate agricultural physicist, and J. P. Wentling, associate forester, resigned. M. H. Reynolds, in charge of veterinary work at the station for the past 25 years, died in January, 1929.

L. E. Miles succeeded D. C. Neal as plant pathologist at the Mississippi station, the latter having resigned to accept a position in the United States Department of Agriculture. L. M. Ware was appointed horticulturist, and G. R. Sipe was transferred from the extension service to the station as head of the poultry husbandry work. S. J. Greer was appointed assistant director of the Pecan branch station recently established in Adams County, and W. R. Perkins succeeded E. B. Ferris as assistant director at the South Mississippi Branch Station. J. O. Smith was added to the staff of the Delta Branch Station as agricultural engineer.

J. W. Barger, associate in rural sociology at the Montana station, resigned, effective October 1, 1928.

E. E. Brackett was made acting head of the department of agricultural engineering at the Nebraska station during absence on leave of O. W. Sjogren, chairman of the department.

T. B. Charles succeeded A. W. Richardson as poultry husbandman at the New Hampshire station, assuming his duties August 1, 1928. C. L. Martin was appointed veterinarian at this station.

The New Jersey stations reported the appointment of Sante Mattson as associate soil chemist to give special attention to physical properties of soils.

G. N. Stroman was appointed associate agronomist at the New Mexico station to take up improvement work with cotton. Mary L. Greenwood was employed as research specialist in home economics.

A. C. Beal, floriculturist at the New York Cornell station for 21 years, died in May, 1929. J. E. Knott, of Pennsylvania, was added to the station staff for research work in vegetable gardening, and A. G. Newhall, of Ohio, for work in plant pathology. G. P. Scoville, research professor of farm management, resigned to accept a position in the United States Department of Agriculture.

P. J. Parrott, chief in research in entomology, was named as vice director of the New York State station. J. J. Willaman, of Minnesota, was elected to succeed L. L. Van Slyke as chief in research in chemistry, and J. G. Horsfall succeeded L. K. Jones as associate in research in plant pathology, both appointments effective February 1, 1929. New appointments in the rank of associate included those of B. R. Nebel in research in horticulture and G. E. R. Hervey in research in entomology. R. C. Collison, chief in research in agronomy, was transferred to the division of horticulture, with the title of chief in research in orchard-soil investigations. J. E. Mensching, associate in research in agronomy, resigned. W. P. Wheeler, associate in research in animal husbandry, retired after 41 years' service with the station.

The North Dakota station reported the transfer of G. J. Baker from the extension service to the position of assistant chairman of the animal husbandry division, effective in October, 1928. Mayme Dworak, bacteriologist and plant physiologist, resigned to continue advanced studies at Pasteur Institute at Paris.

C. W. Bennett was appointed associate plant pathologist at the Ohio station. C. E. Dike of the agronomy department was made superintendent of the new farm established in Henry County. J. H. Gourley, chief of the horticultural division, assumed also the duties of head of the horticultural department of the College of Agriculture of Ohio State University, and R. M. Salter, chief of the agronomy division, the duties of chairman of the department of soils at the college.

H. F. Murphy, associate in farm crops and soils at the Oklahoma station, was made acting head of the department in the absence of A. A. Daane, on sabbatic leave for advanced work. J. C. Ireland succeeded Fred Griffiee in plant-breeding work. In the department of agricultural economics O. W. Herrmann and P. H. Stephens were appointed associates vice W. W.

Fetrow and J. O. Ellsworth, respectively. J. F. Page, associate agricultural economist, relinquished station duties to devote his entire time to teaching. A. C. Baer, for the past 10 years head of the department of dairying and dairy husbandry, died January 7, 1929. A. D. Burke, his associate, was made acting head of the department.

F. E. Price was transferred from the extension service to the Oregon station staff as agricultural engineer, vice G. W. Kable, resigned, and M. R. Lewis was appointed drainage engineer, cooperating with the Bureau of Public Roads of the United States Department of Agriculture.

T. E. Odland of West Virginia succeeded B. L. Hartwell as agronomist at the Rhode Island station, effective February 1, 1929. J. B. Smith, associate chemist, was made chemist, and F. R. Pember returned to the station as associate. F. T. McLean, plant physiologist, resigned in July, 1928, his duties being assumed by the station director.

R. A. McGinty was appointed horticulturist at the South Carolina station, assuming his duties July 1, 1928. G. M. Armstrong, in charge of cotton research at the Pee Dee substation at Florence, was transferred to the main station as botanist and plant pathologist, and J. M. Wallace was added to the staff as associate. E. C. Elting succeeded K. S. Morrow as associate dairyman.

The South Dakota station appointed K. W. Franke chemist vice B. A. Dunbar, who was relieved of station work to devote his time exclusively to teaching. K. H. Klages of Oklahoma was appointed associate agronomist.

Helge Ness, botanist at the Texas station for the past 40 years, died December 30, 1928, and W. S. Hotchkiss, superintendent of the Troup substation, died July 14, 1928.

H. J. Pack, entomologist at the Utah station, was appointed acting head of the department of zoology and entomology at the college.

Appointments in the rank of associate at the Vermont station included A. R. Midgley in agronomy and O. M. Camburn in dairy husbandry. A. H. Robertson, dairy bacteriologist, resigned, effective October 1, 1928, to take the position of dairy bacteriologist for the New York State Department of Farms and Markets, and A. H. Gilbert, associate plant pathologist, resigned July 1, 1928, to become head of the department of plant pathology

at Macdonald College, Province of Quebec, Canada.

R. E. Hunt and I. D. Wilson, of the Virginia Polytechnic Institute, were added to the station staff, the former as animal husbandman and the latter as zoologist and animal pathologist, both appointments effective October 1, 1928. D. C. Heitshu, agricultural engineer, was assigned to the station for full-time work, succeeding V. R. Hillman, who was transferred to the teaching staff.

L. K. Jones, of Geneva, N. Y., was appointed associate plant pathologist at the Washington station, effective September 1, 1928, and F. R. Yoder was added to the staff as rural sociologist. Evelyn H. Roberts succeeded Inez J. Arnquist as research specialist in home economics.

H. O. Henderson, associate animal husbandman at the West Virginia station, was made head of the department, succeeding E. L. Anthony, resigned. W. H. Pierre, of Alabama, was appointed associate agronomist and F. J. Schneiderhan of Virginia associate plant pathologist.

Among major appointments at the Wisconsin station were W. V. Price in dairy husbandry and W. P. Mortenson and E. L. Kirkpatrick in agricultural economics. John Swenehart, agricultural engineer, resigned January 1, 1929. W. H. Wright, agricultural bacteriologist at the station for some 20 years, died May 3, 1929.

A. R. McLaughlin was appointed pharmacologist in the department of research chemistry at the Wyoming station.

MARY A. AGNEW.

A. C. TRUE

In the death of A. C. True, April 23, 1929, there passed away one to whom agricultural education and research owes a great debt. During the long period of his connection with the Office of Experiment Stations and in his relations with the experiment stations, he was influential in the establishment and maintenance of sound policies and high standards of research in agriculture. Within this period a great system of agricultural research was developed. Many others, of course, have played important parts in this development, but it may be conservatively said that no single individual better served or more permanently benefited the cause of agricultural education and research during its critical formative period and early development.

STATION PROJECTS

Agricultural research at the experiment stations is conducted largely on a project basis; that supported by the Adams and Purnell funds being wholly in the form of projects, which are submitted to the Office of Experiment Stations for approval before they are undertaken.

There appears to be general recognition of the advantage of conducting the station work on the basis of carefully formulated projects, and agreement as to the essentials of a well-planned project, viz, that it shall be clear-cut and specific in title and objective, up to date in the procedure to be followed, and designed to provide for thoroughgoing investigation which takes due account of previous work. Adams and Purnell projects submitted to this office for approval are examined carefully for conformity to these requirements.

ADAMS PROJECTS

During the year there were in active operation 447 projects supported by the \$720,000 made available by the Adams Act, and by supplementary funds from other sources, which brought the estimated total up to more than \$1,000,000.

During the year 84 Adams projects, or about 20 per cent of the total, were completed or revised, indicating that the average life of an Adams project is five years. This does not necessarily mean that the average Adams project is completed in this time, but rather that the problems in mind when a project is initiated become modified sufficiently in a 5-year period, through the findings in the project itself and the advance made by others in the same field, to warrant restatement. Such revision of the older projects has been encouraged by the office. It is thought that this not only furnishes a more accurate record of work under way but enables the investigator to adjust his work more effectively to the general advance in his field of research. It also tends to bring out how his endeavors are fitting in with the problems in his field and the specific phase on which he is attempting to make his contribution.

Adams projects embrace practically all the subdivisions of agricultural research with the exception of agricultural economics and sociology, but as is quite well understood, have been restricted to research of a fundamental

nature. The classification of Adams projects by subjects showed that there were 83 in plant diseases, 61 in soils and fertilizers, 57 in genetics, 52 in entomology, 41 in horticulture, 38 in animal production, 37 in veterinary medicine, and smaller numbers in other subjects. The estimated allotments of the Adams funds to the projects in different subjects on which major emphasis was placed were approximately \$109,000 for soils and fertilizers, \$93,000 for plant diseases, \$90,000 for animal production, \$79,000 for genetics, and \$69,000 for veterinary medicine.

The States reporting the amounts of supplementary support for Adams projects indicated that the Adams fund was more than equalled by State funds in projects in plant pathology. The supplementary support furnished from State funds to Adams projects in other subjects was relatively less.

PURNELL PROJECTS

The \$2,400,000 provided by the Purnell Act, supplemented by funds from other sources—amounting to about \$600,000—supported 1,186 projects during the year.

The number of projects per station varied widely. One station had 7 projects, and another 9, whereas several of the stations had as many as 40 active projects. Of the total number, 281 were new projects, and 169 were completed during the year. It was found desirable to restate 47 of the projects either because progress in the studies seemed to require modifications in the procedure, or because the adequacy of the original plans was questioned.

The appropriation of \$20,000 to each State when the Purnell Act was passed in 1925, with the subsequent increases of \$10,000 a year, involved in some cases a considerable expansion in the activities of the experiment stations. Consequently, a number of preliminary undertakings were set up to develop particular types of investigations in new fields, which might warrant more intensive study. The 169 projects completed during the past year indicated that this plan was being followed. Many of the preliminary studies have been replaced by more fundamental and intensive research, based on sounder and more adequate methods dealing with important problems discovered in preliminary surveys. A number remained which were designed to contribute immediate information on problems of practical interest although these may

be expected to develop into projects of a more definite research character when the preliminary findings warrant revision along more scientific lines.

The Purnell fund is being used to support studies in a wide range of subjects related to agriculture. In addition to the other fields of agriculture mentioned in the Hatch and Adams Acts, the Purnell Act specified agricultural economics, rural sociology, and home economics. Consequently projects in these fields have received particular attention. Because of the relatively recent development of investigations in these subjects many of the projects have been of a pioneer nature. However, progress is being made in developing methods of research comparable with those employed in the older lines of investigation.

Of the 319 projects active in agricultural economics during the year, 73 were completed and 78 were new undertakings. The total support from the Purnell fund from all stations for agricultural economics projects was approximately \$705,000, with supplementary support of \$75,000, reported by 30 States. There were 131 active projects in home economics, 27 of which were new undertakings and 27 were completed. The total allotment of funds for these studies was \$264,000, with supplementary support from other funds of \$25,000 for the States reporting. In rural sociology there were 39 active projects, 12 of which were completed and 8 new undertakings. The total allotment from the Purnell fund for rural sociological investigations was \$69,000, with supplementary support of \$7,500.

The number of projects in other subjects to which considerable portions of the Purnell fund were allotted were as follows: Animal production 132; horticulture 97; plant diseases 73; field crops 71; entomology and zoology 69; animal diseases 53; soils and fertilizers 51; and agricultural engineering 51. There were fewer projects in the other fields. The support from other funds, in addition to that supplied from the Purnell Act, amounted to a little more than 10 per cent for agricultural economics, rural sociology, and home economics, while some of the other fields had considerably more, e. g., entomology and zoology 22 per cent, animal production 23 per cent, and genetics 40 per cent.

GEORGE HAINES.

COOPERATION

Cooperation between the experiment stations themselves and between the stations and the Department of Agriculture made substantial progress during the year. The record at the end of the year showed nearly 1,100 active cooperative projects. The number of projects recorded the previous year was about 900, a net increase of about 200, or about 22 per cent.

These cooperative projects were distributed quite widely among the various branches of agricultural research—322 in plant improvement, plant genetics, cereal, forage, and other field crops, pastures and ranges, horticulture, pomology, and plant diseases; 299 in agricultural economics and rural sociology; 121 in animal production, animal pathology, and animal genetics; 115 in soils, soil surveys, soil fertility, fertilizers, and chemistry; 90 in entomology and zoology; 52 in agricultural engineering; 47 in dairy husbandry; 26 in forestry; 11 in human foods, nutrition, and home management and equipment; and 3 in meteorology.

All of the States were represented in these cooperative enterprises, the stations in California, North Carolina, Washington, Minnesota, Montana, and Wisconsin leading, with 49, 47, 43, 40, 39, and 36 projects, respectively. While the maximum numbers for individual States showed little increase over the previous year, the distribution among the States was more general, reflecting the extended scope of this joint action during the year.

The record also indicates that about 20 major regional projects were in operation during the year which involved the cooperation of groups of States varying in number from 3 to 34 and usually including from one to three bureaus of the Department of Agriculture. Of those involving department cooperation, the work on quality of meat, oil sprays, spray residues, cereal and forage crop insects, and the growth of wool were especially characterized by completeness of organization and effectiveness of operation.

Of the 1,100 cooperative projects 136, or 12.5 per cent, involved support from the Purnell fund. Of these, 85 were in agricultural economics and rural sociology; 19 in animal production, animal pathology, and animal genetics, 13 in plant industry, 3 in entomology, 4 in agricultural engineering, 1 in soils, 2 in dairy industry, and

9 in home economics. The use of the Adams funds to support cooperative projects was considerably more restricted, there being only 16 such projects receiving support from that source. Of these, 10 dealt with features of plant industry, 2 with animal industry, 3 with agricultural engineering, and 1 with chemistry. Evidently a large proportion of the cooperative projects were supported by State funds.

A very large proportion of the cooperative projects included collaboration with the Department of Agriculture. In fact, the formal cooperation under agreements which define the terms of participation of the cooperating parties has been largely between the experiment stations and the department. Such terms of agreement or understanding are recognized as desirable by both agencies. It appears that proposals for cooperating on such a basis originate most frequently in the bureaus of the Department of Agriculture, although such suggestions not infrequently are initiated by the stations themselves.

In addition to formal cooperation, there is a type of correlated research growing out of group meetings or conferences of workers in a limited, common field. Despite the informality of such cooperation, usually there has been nominal or accepted leadership to give it purpose and direction. In the less advanced fields the effort has been largely to initiate more definite studies of problems and to organize the inquiries along specific lines.

When the Purnell fund became available in 1925, the joint committee on projects and correlation of research, representing the Association of Land-Grant Colleges and Universities and the Department of Agriculture, set up certain projects of national scope as a basis for broader and more effective correlation of research. The department has maintained close relations with the committee and has kept the chairmen of the various subcommittees dealing with the individual projects informed of new projects undertaken by the stations to assist them in the organization of their subjects. In a recent report, however, the committee states² that cooperation in these projects—

has not made notable headway in most lines. . . . Such an organization of the projects as would insure their being covered systematically and recognized responsibility for integral parts has rarely been effected. Consciousness of membership in a common cause has not been a conspicuous product of operations under the national projects.

The committee therefore recognizes the need of more effective means of bringing about correlation.

The general trend toward cooperation in research strengthens the belief that the broader relationships should receive full consideration in planning station programs and especially in inaugurating new projects or lines of investigation, with a view to more effective correlation of effort.

INSULAR EXPERIMENT STATIONS

In accordance with the policy of Congress, agricultural experiment stations are maintained by the United States Department of Agriculture in Alaska, Hawaii, Porto Rico, Guam, and the Virgin Islands. These stations are under the administrative supervision of the division of insular stations, Office of Experiment Stations.

The stations receive their entire support from appropriations made by Congress, and their respective incomes for the fiscal year ended June 30, 1929, were as follows: Alaska, \$85,000; Hawaii, \$54,940; Porto Rico, \$56,640; Guam, \$25,000; and Virgin Islands, \$25,000. The proceeds from the sale of products, which were deposited in the Treasury as miscellaneous receipts and were not available for station maintenance, amounted to \$5,009.59.

The policies of the stations have not been changed materially. The investigations are concerned principally with the possibilities of diversifying the existing agriculture or developing types of agriculture that are adapted to the different regions.

ALASKA STATIONS

On account of the extent of the Territory and the wide differences in climate and topography, stations are maintained at Sitka, Fairbanks, Matanuska, and on the island of Kodiak.

At the Sitka station, which is located in southeastern Alaska, a timbered region of rugged topography, and heavy rainfall but not severely cold winters, the work is mainly with vegetables and small fruits. On account of climatic conditions and the absence of extensive areas of land that

²MUMFORD, F. B., MERRILL, E. D., WOODS, A. F., TAYLOR, W. A., ALLEN, E. W., and COOPER, T. REPORT OF THE COMMITTEE ON PROJECTS AND CORRELATION OF RESEARCH, 1929. Assoc. Land-Grant Col. and Univ. Proc. Ann. Conv. 43:203. 1930.

can profitably be brought under cultivation, this region is preeminently fitted to truck growing and the family garden.

The station, from the time of its establishment, has devoted its activities to testing fruits and vegetables to determine their adaptability, and it has carried on plant-breeding experiments by which, through selection and crossing, have been developed varieties that are superior in a number of ways to varieties of the same crops that were introduced from regions having widely dissimilar conditions. The work in producing hybrid strawberries that are hardy in most regions of Alaska where they have been tested and that with seedling potatoes are outstanding in results. Methods of growing many kinds of vegetables have been developed, and the presence of gardens in almost every town and village attests the value of the station's work.

At the Fairbanks station the principal lines of work are concerned with cereals, forage plants, and livestock. Ability to mature crops within an average frost-free period of about 95 days is the main problem in agronomy. Plant-breeding experiments have resulted in the production of varieties of wheat, barley, and oats that grow and ripen within this period, and their yields over several years have been considerably in excess of the general average for these crops in the United States.

At this station an experiment has been in progress for several years in crossing the Asiatic yak with Galloway cows in order to produce a hardy beef animal for the interior of Alaska. Progress on this project has been very slow by reason of the limited number of animals, but some F_1 and F_2 generation crosses have been under observation for some time and their ability to withstand the winter's cold with a very limited quantity of feed is undoubted. One of the cows, during a relatively short lactation period, gave a fair quantity of milk that tested over 6 per cent butterfat. The only male of the cross that was old enough for breeding purposes proved to be sterile. This confirmed observations, said to have been made in Germany, that first-generation males of yak-cattle crosses are sterile. All the females produced thus far have been fertile.

The work at the Matanuska station, which is located about 320 miles south of Fairbanks, is mainly experiments

in general crop production and in dairying. At this station the average frost-free period is about 115 days, and some varieties of grain have ripened that did not mature at Fairbanks. Plant-breeding experiments have resulted in the production of varieties of wheat, oats, and barley, many forage plants, and root crops that can be depended on to yield good returns in the average season.

The work in dairying consists mainly in establishing a new type of dairy cow that will be hardier and a better rustler than the common dairy breeds. Crosses have been made between the Galloway and Holstein breeds, and the F_1 and F_2 generations are being compared with purebred animals of each breed. One F_1 cow gave 12,010 pounds of milk in her fourth lactation period, and three F_2 cows each gave 8,000 pounds during the first lactation. Genetic data are on hand for each animal, and the dominance of Galloway characters of color and absence of horns is clearly indicated. All of the crossbred animals are as hardy as the Galloways and exceed them in milk yield.

The work on Kodiak Island is carried on at Kalsin Bay, some 15 miles from the village. The principal experiment consists of the maintenance under range conditions of a small purebred herd of Galloway cattle to determine their winter management. This region is representative of a vast treeless area in southwestern Alaska where summer pasturage is abundant, but by reason of much rain and many cloudy days haymaking is very uncertain. A solution of the wintering problems for livestock will mean much for this region.

Congress, by an act approved February 23, 1929, extended the Hatch Act to Alaska with the proviso that no appropriations should be made under this act until the Secretary of Agriculture should determine the ability of the Territory to make effective use of the funds. The Secretary of Agriculture proposed certain conditions relating to buildings and personnel as preliminary to the extension of the Hatch funds to the Territory, and a bill was introduced in the Territorial Legislature to provide for them, but it failed of passage. When the conditions are met, it is probable that the Fairbanks station will be turned over to the Agricultural College and School of Mines located near Fairbanks.

HAWAII STATION

The extension work in agriculture, which was inaugurated by the experiment station in 1915 and has been carried on for 14 years, was turned over to the University of Hawaii Extension Service during the year. The extension of the Smith-Lever Act to Hawaii in 1928 made this possible, and it will enable the station to confine its efforts to research work directed toward the development of agricultural production that may supplement the sugar and pineapple industries, which now constitute the main agricultural activities of the islands. During the time that the station was engaged in agricultural extension activities, the basis was established for work with homesteaders and other small farmers. The personnel of the station that was engaged in extension activities was transferred to the university during the year, and the work was continued and considerably extended.

By the act of May 16, 1928, the Hatch and supplementary acts, which give aid to agricultural investigations, were extended to Hawaii, with some limitations. This act became effective July 1, 1929, and under its provisions a close coordination of the work of the Federal station and that to be carried on by the University of Hawaii was provided for. By agreement between the Secretary of Agriculture and the president of the university, the two institutions have been integrated into one under the director of the Federal station, and the institution is to be known as the Hawaii Agricultural Experiment Station. The joint institution will be supported by appropriations made to this department for continuing research in tropical agriculture, funds granted to the Territory under the above act, and appropriations made by the Legislature. The new institution has started off very auspiciously, and with the local support that is now assured, progress should be made on problems of interest not only to Hawaii but to other tropical countries.

The research of the station was actively pursued during the year. Studies were made of methods for the propagation of numerous tropical horticultural plants, with a view to establishing improved varieties and strains, and considerable progress was made with a number of plants that had not responded to the usual methods of budding and grafting. Through the investigations of the station of the

Macadamia nut as a minor crop, a number of large commercial plantings have been made. A successful method based on the specific gravity of the nuts was worked out for determining their maturity. Interest has been aroused in the native species of raspberry, which furnish a very large fruit, and experiments are in progress on crossing them with domesticated raspberries, and on methods of propagation and cultivation.

Considerable additional data were secured as to areas adapted to the growing of the edible canna for the commercial production of starch and on the peculiar constitution of the starch and its possible uses. The starch studies have brought out some interesting facts as to the colloidal behavior of the starch solution, and the viscosity and swelling power of starches. A number of extensive areas that appear to be well suited to the growing of edible canna have been found and studied, not only from the standpoint of soils and climate, but also in reference to their location in respect to manufacturing, development, and convenience to markets. Attention was given to studies of the coffee soils of the Kona district on the island of Hawaii, and some striking differences were found that may be of importance in the extension of the coffee industry. Data on chemical and physical characters of Hawaii soils were accumulated as a basis for their proper classification and uses.

The work of the substation on the island of Maui is assuming importance. As a result of its investigations, pineapple planting has been extended more than 500 feet in elevation beyond what was formerly thought to be the limit. This makes available a considerable area on the slope of Haleakala Mountain for the extension of pineapple plantings.

PORTO RICO STATION

The hurricane of September, 1928, which devastated the island, wrought severe damage to the station and its work. Some of the buildings were destroyed and others badly damaged. The plantings for some of the long-time experiments were so injured as to require their renewal and the resumption of the experiments under modified plans. The station fortunately was in possession of much information relating to the behavior of various leading crops, and it took an important part in the work of restor-

ing the agricultural industries of the island. This was especially the case with the coffee, citrus fruit, and pineapple industries, and their restoration to normal production seemed possible in a much shorter time than was required following a previous hurricane.

In spite of the losses and interruptions due to the hurricane, the station at Mayaguez made considerable progress with its investigations. The orchard plantings of the station were so damaged that several years must elapse before they are in normal bearing. In the meantime attention was turned to crops that are produced within a comparatively short time. Many of these are among the leading food crops on the island, and important data were added to information already on hand as to varieties and planting material. All of this information was available to planters and others, and contributed very materially to the immediate support of the people.

The plant-breeding projects have yielded valuable results, not only in the scientific data obtained but in the establishment of new and valuable varieties. The sweet corn variety developed by the station was given extensive field tests in several localities on the island. The sugarcane breeding experiments were continued, and approximately 2,500 new seedlings from crosses of known parentage were grown during the year. A number of seedlings from controlled crosses have been tested during several years, and some of them have been found to be practically immune to mosaic, and at the same time to possess good agronomic characters.

The studies of animal parasites have yielded valuable information on the occurrence of species, their abundance and distribution, and life histories. Especial efforts are being made to find the intermediate hosts of some of these parasites as a possible factor in the development of control measures.

The work on problems connected with the citrus and pineapple industries is carried on mainly at the San Juan laboratory. Some of the investigations connected with the fruits were interrupted through the damage done by the hurricane. Many trees were blown over or broken, and practically all fruit was stripped from them. The station rendered great service to growers through suggestions

as to raising, staking, and pruning the trees and fertilizing them to promote rapid growth. Immediately following the storm a survey was made of the losses sustained by the citrus and pineapple industries, and the data were made available to the Porto Rico Hurricane Relief Commission. For several years there have been in progress studies of various factors concerned in the production, handling, and shipment of fruit, and through the efforts of the station a credit association and a central committee which represents all of the fruit growers were formed.

GUAM STATION

The Guam station continued to cooperate with the insular government and the schools in various enterprises for the improvement of the agriculture of the island. Since there are no private nurseries or other local sources from which planting material of improved varieties can be obtained, considerable attention was given to the production of the material for distribution to farmers and others. The station continued to supervise experiments on the island government farm, especially with forage plants grown to provide forage for the livestock belonging to the island government.

The station assisted materially in the establishment of a new industry on the island. As a result of previous experiments at the station in growing pineapples, a local organization has undertaken plantings for canning purposes, and more than 150,000 plants were set out during the year. Should this venture prove a success, another agricultural industry will be added to the limited number now on the island. The plants were obtained from Hawaii through the cooperation of the Guam and Hawaii stations.

The experiments in the improvement of the livestock of Guam by the use of improved sires are being continued. Coupled with livestock improvement is the question of better pastures and more economical feeds. Adaptation tests of a large number of introduced grasses and leguminous forage plants have shown a number of species to be well adapted to Guam conditions and far superior to the local species. Palatability tests of a number of the most promising forage plants have been made by grazing calves on the plats, and while differences were observed in the preference for certain species of grasses, all were

grazed much more readily than were the native grasses.

It had been noticed that cattle grazed on native pastures on savannah or red clay uplands frequently exhibited depraved appetites which were accompanied with some rather definite symptoms of disease. Feeding experiments with bone meal resulted in the improved appearance of affected animals, suggesting that there is a lack of phosphorus and lime in the herbage of savannah pastures.

Continued feeding experiments with cattle, pigs, and chickens have shown that rations composed of locally produced materials are nearly as efficient as those made up of imported feeds. It was found that coconut meal could be safely and profitably substituted for from one-third to one-half of the concentrate fed. This meal, an important by-product of the production of coconut oil, is cheap and fairly abundant.

The coconut-scale situation continued to be satisfactory. Apparently a biological balance has been established between the scale and its active enemies, chief of which is the small ladybird beetle, *Cryptogonus orbiculus nigripennis*. The reappearance of the ladybird beetle, *Novius cardinalis*, in the station orchards is reported. This parasite of the cottony-cushion scale of citrus and other plants was introduced by the station several years ago, but after liberation it seemed to disappear. Its reappearance suggested that conditions are favorable for its growth and distribution.

Considerable attention has been given to the study of internal parasites of poultry and other animals. Successful results have been secured in preliminary experiments with various anthelmintics, and they are being tested on larger scale operations. A number of locally reputed remedies were found to be of little or no value.

VIRGIN ISLANDS STATION

During the year a situation arose in the Virgin Islands that necessitated the appointment of a veterinarian and an animal husbandryman at the station. For a number of years the shipment of cattle to Porto Rico for slaughtering was permitted, and a considerable industry was built up. It was found later that the legislation permitting this practice had been repealed by Congress and the quarantine regulations regarding the movement of livestock would have to be

enforced. Both the Virgin Islands and Porto Rico are tick infested, but under the regulations shipments can be permitted only after dipping and certification that cattle are free from ticks. Since there was no competent veterinarian in the Virgin Islands to attend to this matter, the station added such a member to its staff. He supervises dipping operations, inspects the cattle, and certifies to their freedom from ticks. In addition, he has begun a study of other diseases of animals, and has undertaken investigations looking toward the improvement of livestock in general.

The work on some of the lines of station investigation was interrupted by the hurricane of September, 1928. Much damage was done to the buildings and to the permanent plantings as well as to some that had been made shortly before the storm. This condition seriously affected the experiments on growing vegetables for shipment to New York during the winter, as poor stands were secured in many cases.

The experiment in the production of new varieties of sweetpotatoes by growing seedlings has progressed very well. From three to six years' tests of a number of the seedlings were reported. When they were grown in comparison with a standard local variety, increased yields of from 1.8 to 46 per cent were recorded. One new variety was outstanding in quality and increased yield.

In the experiment in growing vegetables as a winter crop for shipment to New York, due to the poor stands mentioned above and the fact that the New York market was plentifully supplied from Cuba, the Bahamas, Mexico, and Florida, prices were so low that most of the shipments were made at a loss. While the primary object of this experiment was the shipment of vegetables to New York in order that a new agricultural industry might be developed, it had a beneficial effect in that many of the natives have begun to grow vegetables on a considerable scale for home consumption and thus have added materially to their dietary.

The sugarcane-breeding work and introduction and testing of varieties from other tropical countries have been continued without serious interruption. The station is continuing its tests of seedlings produced in 1926, 1927, and 1928, and while most of them have been eliminated as no better than standard varieties, there are a few

that are outstanding in their yield of cane, purity of juice, and resistance to disease. Some of these are being given field trials. One of these new varieties originated from SC 12/4, a variety developed by the station in 1912 and reported to be one of the best varieties for growing without irrigation in St. Croix, Porto Rico, Cuba, and elsewhere.

On account of developing the cattle industry, attention has been given to the introduction and testing of a considerable number of grasses and other forage plants to supplant or supplement the common guinea-grass pastures. Some of the introductions appear very promising, but will have to be tested on a larger scale before definite recommendations can be made.

The cooperative demonstration work on St. Thomas has given very promising results. Vegetable growing has been adopted by many as a result of the showing made in the experimental plats. Interest has also been aroused in poultry raising. The representative of this station traveled nearly 1,500 miles on the islands of St. Thomas and St. John during the year in connection with his cooperative undertakings.

WALTER H. EVANS.

RESULTS OF STATION WORK

Research at the experiment stations continued to furnish solutions for many of the practical problems of agriculture. The following summaries, prepared by specialists of the Office of Experiment Stations, review a few examples of recent investigations which provide information of more general interest and application.

SOILS AND FERTILIZERS

The year's work in general shows activity in the more familiar soil and fertilizer projects to have been intensified and extended. It has seemed best, however, that the review of this year be devoted largely to the brief presentation of certain of the more recent developments.

Infertile soils.—Investigation of the saline or so-called "alkali" soils has been continued by a number of the stations, and the gradual reclamation of such lands has gone on in general with little or no striking modification of method or result. Progress in such improvement work has been shown by the California station and others. The Idaho station found that of the chemical changes observed in the usual

treatment of alkali soils, the conversion of carbonates to bicarbonates showed the most marked correlation with improved crop growth. At the Nevada station a study of the possibly related problem of "slick spots" showed such soil to be practically free from water-soluble carbonate and bicarbonate and to contain but a trace of sodium nitrate, so that neither the "black alkali" nor the "niter soil" condition could account for the slick spots. It was concluded that the slick spot results probably from factors entirely different from those of ordinary alkali conditions.

Two more or less closely related agencies which have caused serious deterioration of farm lands are the deposit of flood silts and erosion.

Experiments on flood silts, begun by the New Hampshire station on deposits laid down to a maximum depth of about 20 inches by the Connecticut River Valley floods of 1927, have indicated potassium and phosphorus deficiencies as primary limiting factors. Organic matter and nitrogen, also, were too low for maximum yields. Good crops of alfalfa, sweet-clover, and timothy were made possible either by manuring at the rate of 20 tons to the acre or by treatment with 800 pounds of a fertilizer containing 12 per cent of phosphoric acid and 6 per cent of potash. The pH values of these flood silts were found to be markedly higher than those generally observed in New Hampshire soils.

Certain erosion and run-off problems are under investigation at the Texas, Virginia, and Missouri stations. The Virginia station found that applications of phosphate and green manuring with cowpeas and with rye, followed by liming, the growth of a hay crop, and the establishment of a rotation of corn, wheat, and grass and clover made possible the production on a badly eroded and very poor hillside field of substantial yields of corn, wheat, and hay. Plant nutrients lost in the erosion waters were found by the Missouri station to include calcium, sulphur, magnesium, and potassium in quantities decreasing in the order named. The nitrogen loss was relatively small.

Acidity and the relation of soil reaction to plant disease.—The nature of soil acidity and its relation to apparent lime requirement, basic nutrient content, the physical properties of the soil, and to the ability of plants to resist root-dis-

ease organisms have been subjects of recent investigation by certain of the stations.

At the Wisconsin station soil acidity and the base-exchange capacity of soils were found to be apparently attributable to an aluminosilicic acid which can be isolated both from the mineral bentonite and from soils. In the form of the free acid this compound was capable of being leached out of the soil as a colloidal solution, and left the soil, in some regions of much rainfall, acid-free even in the absence of a detectable lime content. Investigations by the Michigan station indicated that organic acids adsorbed in the aluminosilicic acid complexes are not reached by certain of the methods for determining soil acidity. The inversion of sugar by acid soils, for example, appeared to be an effect of the soluble acids only. At the Ohio station the pH value seemed to give a good indication of the degree of saturation with exchangeable bases.

The work of a number of the stations has indicated that even a quite markedly acid condition may not be necessarily a primary limiting factor in crop production.

The Oregon station found the available supply of essential ions apparently more important to crop production than the degree of acidity or even the concentration of toxic ions. Some highly acid soils producing good crops of alfalfa were found by the Wisconsin station to contain an average of 565 pounds of available calcium to the acre, with 27 pounds of soluble phosphorus to the acre. Soils of like acidity but containing only 346 pounds of calcium and 15 pounds of phosphorus produced poor alfalfa crops. The Pennsylvania station found that De Kalb silt loam surface soil, in which only the exact indicated lime requirement had been supplied, gave the best root development of alfalfa, though the liming had not actually neutralized the acidity. An excess of lime appeared detrimental both to the root development and to the yield of the crop. Certain soils studied by the Nebraska station appeared to require no lime, regardless of the pH value, when the organic-matter content was relatively high.

A definite influence of the reaction of the soil, both upon beneficial soil organisms and upon certain plant-root diseases, has been indicated in recent investigations.

Legume bacteria, for example, were observed at the Wisconsin station to

disappear very rapidly from strongly acid soils, whereas in certain soils showing little or no acidity fresh inoculation gave little or no increase in yield, although the land used had not been in peas for 10 years.

The relation of soil reaction to plant disease finds striking illustration in the control on New England soils of the black root rot of tobacco by a method developed by the Connecticut station, and in similar work of the Massachusetts station. The Connecticut station was able to show that soil acidity is not a limiting factor in tobacco production at pH values above 5, whereas the root rot was not found where the soil pH value was below 5.6. The Massachusetts station also found that a pH value of 5.6 or lower definitely inhibited the root rot. At temperatures of 15° C. and above, however, the critical pH value rose slightly with the temperature.

An influence of soil reaction upon cotton root rot and upon *Fusarium* wilt of cotton was indicated in the finding of the Texas station that the root-rot fungus was most active at about pH 7, its growth in the laboratory being inhibited, however, only when the pH value was reduced to pH 4.1 or raised to 8.9. In the field the organism was found at pH values of from 5.5 to 9. The *Fusarium* wilt, on the other hand, was most abundant in acid soils, although its growth was not always inhibited by neutrality, and in two cases the wilt organism was found in actually alkaline soils. A pH value above 7.4 is stated by the New Jersey stations to have prevented the appearance of the club-root disease of cabbage, a slight infection appearing always with the lowering of the pH value to 7.1, with, as a rule, 100 per cent infection at pH 5.7 to 5.8.

Moisture and related physical factors.—Of field-soil treatments investigated in relation to their effect on soil moisture by the New Jersey stations, the addition of organic matter increased the soil moisture content, whereas liming decreased it. The positive effect of the organic matter was about twice the negative effect of the liming, however.

The subsoil moisture content was found by the Kansas station to vary but slightly below the fifth foot under ordinary conditions. From the soils studied the moisture was taken up soon after it had fallen and before it had penetrated to any great depth. From an investigation of the California station was drawn the conclusion

that if the soil is wet at the beginning of the growing season to the full depth of normal root penetration, subsequent rainfall or irrigation can have probably but little influence upon the extent of the development of the root system.

In heavy plains soils the Oklahoma station found that about 20 per cent of the total annual rainfall became subsoil moisture. Only such cultural conditions as remove moisture very rapidly, deep plowing or plant growth, for example, appeared to threaten the immediate loss of a body of stored moisture. The temperature, under the conditions of this investigation, had a relatively slight effect upon the quantity of moisture stored or upon the rate of gain of moisture in the soil, but appeared highly significant in modifying the relationship of rainfall, wind, and humidity to the behavior of soil moisture. At the California station soil mulch was shown materially to reduce the evaporation from a soil having a water table less than 4 feet below the surface. An experiment upon an alkali soil at the same station indicated 8 feet as a close approximation of the maximum height of the capillary rise.

Mineral nutrients.—The cost of transportation of inert material lends an increasing interest to fertilizer of relatively high total nutrient content and to the no-filler mixture. The Vermont station has observed in case of mixed fertilizers sold in that State that whereas the mixtures containing 14 per cent or more of actual plant food had an average price about 30 per cent higher than that of the mixtures of lower analysis, the average content of actual plant food was greater by about 60 per cent.

A study of the computations involved in the proportioning of no-filler mixtures has been made by the Massachusetts station. An algebraic method of calculation was elaborated; the triangular system was found useful for the indication of ratio possibilities but inadequate for computing no-filler mixtures; and it was shown that in general single-element components widened the ratio possibilities, whereas double-element components increased the no-filler possibilities.

Recent station work on phosphates has taken for the most part the usual directions. A tendency of water-soluble phosphate to rise toward the surface of the soil was noted by the Michigan station. This station also found that soils showing less than 0.5

part per million of phosphorus in the water extract usually responded to phosphatic fertilizers, whereas soils of which the extract showed 3 to 4 parts per million of phosphorus made little or no response. Where phosphatic fertilizers had given markedly increased yields the soil solution was found to carry 1 part per million of phosphorus or more. Certain of the soils studied appeared to have so high a capacity for fixing phosphates as to necessitate the application of relatively large proportions of the element.

The question of the availability of rock phosphate has continued under investigation at a number of the stations. The Illinois station reported on experiments in which rock phosphate with gypsum was superior in its effect upon corn to superphosphate supplying the same quantities of phosphorus and of sulphur, although in cases of every other crop the yields from the two treatments were closely similar.

The appearance of the bone-eating habit in cattle, apparently due to a deficiency of phosphorus in hays and grains, led to experiments by the Montana station in which it was found possible to increase by phosphating both the yield and phosphorus content, and in some instances also the protein content of alfalfa even on fertile soil.

An effect of potassium deficiency was observed by the New Hampshire station, where a sugar, discovered in normal radishes, was much reduced in quantity when the potassium content of the culture solution was reduced to one-tenth of the normal and practically disappeared when the nutrient solution, otherwise complete, contained no added potassium. Tomato plants showed similar, although less marked, differences. Optimum growth of tomato plants in a continuously flowing culture solution, studied by the California and Maryland stations cooperating, was maintained at a potassium concentration in the solution at the intake of 5 parts per million, with a rate of flow of 8 cubic centimeters per minute for each plant. Lower potassium concentrations were accompanied by decreases in potassium absorption, with a tendency toward increases in the absorption of calcium, magnesium, and phosphates as compared with the controls. Potassium minima were studied also at the Arkansas station, where no relation was found as between the total potassium requirement of plants and the

minimal concentrations permitting optimum growth. Oats, for example, with a relatively low total potassium requirement, and cowpeas, which require a relatively large total quantity of potassium, both needed a minimal concentration in the medium of 2 parts per million of potassium.

Sulphur, according to the results of the Oregon station, was not taken from the soil by commonly grown legumes, forage grasses, and grains in as large quantities as phosphorus; and, at least in two very extensive areas of western Oregon, the sulphur content of the soil was shown never to approximate the phosphorus content. From experiments and calculations of the Utah station it was inferred that although sulphur may become a limiting factor in crop production upon certain of the Utah soils, the time required for this to manifest itself will vary with the soil, the specific irrigation water used, and the crop grown upon the soil. The Idaho station found the most practical method of supplying sulphur to consist in the application of gypsum in the fall or early spring. Sulphur alone, however, gave as good results as did either gypsum or sulphur with lime.

At the Rhode Island station manganese salts have continued to bring about large increases in certain crops on neutral or nearly neutral soils, and similar effects of manganese, as well as of copper, zinc, and some others of the less usually applied elements have been found to be important by the Florida station in its work on sawgrass peat. As in the Rhode Island work on manganese, the effective quantities of zinc and copper salts were found to be relatively very small.

Soil organic matter and nitrogen.—The influence of the soil organic matter on the moisture content has already been noted. That the state of the mineral nutrient ions in the soil may be affected quite markedly by the soil organic matter was indicated by an observation of the Delaware station. In two soils of nearly the same content of electro-dialyzable material, the one soil being of an inorganic nature and the other approximately 90 per cent organic, between five and six times as long a period was required for the completion of the electro-dialysis of the inorganic soil as was needed in the case of the highly organic soil. From this observation it was concluded that a soil rich in organic matter gives up its plant food much more readily

than does one with little organic matter. A quite-possibly related observation is that of the Florida station, which found that green-manure crops appeared to bring about in lysimeter tests a loss of plant food larger, when no immediately following crop was grown, than that occurring where no crop had been plowed down.

From experiments designed to restore or improve the organic-matter and nitrogen content by green manuring comes the rather striking observation of the Illinois station that the crop-producing power of certain soils of low organic-matter content was improved by the mere growing of a sweetclover crop of which both the roots and the tops were removed. The plowing under of the sweetclover in the soil in which it had been grown yielded a greater improvement; but the plowing under of the harvested crop of sweetclover in soil upon which the clover had not been grown did not give an improvement as marked as that following the growth and subsequent complete removal of the sweetclover. The plowed-down sweetclover furnished nitrogen in excess of the needs of the succeeding crop.

The Indiana station found the growing of legumes to be the easiest and most profitable means of restoring nitrogen and organic matter to run-down soils. The Kansas station has reported a comparative study of the decomposition of the residues of corn and of kafir. The kafir appeared to contain in small quantity a carbonaceous substance capable of bringing about a decomposition temporarily more rapid than that of the corn residues. The ultimate effect of the kafir upon the nitrogen content of the soil was believed to have been a stimulation, however, rather than a retardation, of the nitrate accumulation as compared with that occurring in the case of the corn residues.

The production of artificial manures by composting straw and like wastes with sufficient of the common fertilizer chemicals to encourage decomposition has been reported upon by the Iowa, New Jersey, and New York Cornell stations, and investigations in regard to it have been continued at several other stations. The question commonly has been that of the profitableness of the practice on the basis of the time and labor expended.

Soil-nitrate minima for certain crops have been determined by the Rhode Island station. Lettuce, for example,

yielded 40 per cent more on soil carrying approximately 15 parts per million nitrate nitrogen than on a soil carrying but slightly less than 10 parts per million, and the data from other crops were not inconsistent with the predetermined minima. Also at the Rhode Island station a study of soil and plant nitrate contents showed that the determination of the soil nitrates predicts the nitrogen needs of young plants adequately, while plant-solution analyses are more exact for later growth stages. In an investigation of the soil nitrogen in a fallow area of Merrimac silt loam the Rhode Island station showed the loss of easily nitrifiable nitrogen from the upper 2 feet of the fallow plat to be but slight, although weather influences and the activity of soil microorganisms caused marked temporary disappearances of the soil nitrates. Nitrate washed down by rainfall was shown often to be retained in the subsoil, to be returned, under midsummer conditions, with the soil water moving upward to replace that evaporating from the surface.

Nitrates in fallow land were studied also by the Montana station, which observed that fallow soil always contained more available nitrogen than did continuously cropped land or land under a cultivated crop. At the Colorado station the problem of excessive nitrate accumulation was found to be met, in part at least, by the plowing under of straw, cornstalks, or low-nitrogen green manures.

The soil fungi were found by the Wisconsin station to play an important part in the tying up of available nitrogen in organic form following the addition of straw or other organic matter low in nitrogen, the growth of the fungi being stimulated by the increased energy supply. This effect would appear not to be of long duration, however, since most of the fungus tissues decomposed readily in moist soils when the supply of energy material had been used up, and the nitrogen of fungus tissue in the soil was found at least as readily nitrified as that of other organic materials.

Soil microbiology.—The possibility of a new rôle of certain bacteria in soil productivity is suggested by the results of experiments of the New York State station. These bacteria, shown to be abundant in productive soils, were capable of little or no growth in a soil (Volusia silt loam) high in organic matter and nitrogen but dis-

tingently acid and of low crop-producing quality. The carbon content of this soil was found to be adequate for the growth of the bacteria, but the nitrogen, although sufficient in quantity, was not readily available to the organisms. This unavailability could be corrected in the laboratory, and its causes under natural conditions were under investigation. The possible part which such bacteria may play in productivity appears in the statement that the bacteria under investigation are not unlike green plants in their nitrogen requirements, and that it is thought that any treatment of this soil making the nitrogen available to these bacteria will make it also available to crops. The advantage of the relatively brief growth period of the bacteria as compared with the time required for a productivity test with crop plants was also pointed out.

A distinct relation of soil reaction to *Azotobacter* growth has been observed by the Kansas station. The organism disappeared entirely from cylinders of unlimed soil, regardless of the food supply. The limed and inoculated cylinders, whether with or without cropping or the addition of such a carbonaceous food supply as straw, contained *Azotobacter* throughout four years, whereas the unlimed inoculated cylinders retained the organism only during the first two years. A similar effect of liming appeared in tests of various treatments of an upland grass sedge bog at the North Carolina station, in which no nitrification was found to occur under natural conditions. Lime sufficient to neutralize the acidity of this soil greatly increased the bacterial numbers and the production of carbon dioxide by the microorganisms although the fungi were not increased appreciably.

Carbon-dioxide production, nitrification of the soil nitrogen, and, to a lesser extent, the nitrification of added ammonium sulphate, were increased at the New Jersey stations in soils supporting a growth of higher plants, the greater effects appearing during the later stages of growth of the plants.

Equipment and methods for the study of exchangeable bases has, as usual, received attention at a number of the stations. Electrodialysis was critically compared with extraction by means of normal ammonium chloride solution at the New York Cornell station. The results indicated that those

cations which are extracted from the soil by electro dialysis when the current flow is relatively small may represent more nearly the cations which are available as nutrients for growing plants than do those extracted with normal ammonium chloride. Advantages of electro dialysis as compared with neutral salt leaching have been pointed out by the Iowa station; and at the Illinois station the determination as sodium-uranyl-zinc acetate of the sodium extractable from soils by normal ammonium acetate solutions was found to be satisfactory.

Methods and apparatus.—The use of crop plants as indicators of various conditions in the soil, while not new, has undergone several interesting adaptations and critical studies in the work of the past year.

One of the most marked departures from the usual direction of such work was the study by the Rhode Island station of a number of crop plants with respect to their absorption of aluminum from solutions of various aluminum contents and the selection of oats, buckwheat, and millet as most likely to show correlation between the active aluminum in the soil and that absorbed by the plant.

The Connecticut State station, while acknowledging the value of greenhouse pot studies in affording control and critical observation impossible in the field, found it a difficult matter to choose a plant capable of revealing clearly the soil differences under investigation and at the same time otherwise adapted to the purpose. Many crop plants sufficiently sensitive to nutritional deficiencies were shown to be subject to the attack of greenhouse insects or diseases, while others were too variable or required too much space. A Turkish variety of tobacco was found to be satisfactory for the purpose. It showed significant differences both in the total yield and in the character of growth when one or more of the nutrient elements were omitted from the fertilizer ration, and it was not attacked by either insects or plant diseases.

Studies of the means of determining soil hydrogen-ion concentrations and the total acidity of the soil included those of the Ohio station on the quinhydrone electrode, and of the Michigan station on buffer action and acidity determination in acid soils. The Ohio station found the potential drift of the quinhydrone electrode controllable by a sufficiently definite technic to

the point of satisfactory results with soil. The Michigan station's study of acid soils showed that neither the sugar-inversion method nor the Jones test measures the actual total acidity of the soil.

Analytical methods comprise, among others, those of the Wisconsin station for determining calcium in the presence of a considerable group of interfering ions, those of the Wisconsin and Iowa stations for total carbon or soil carbon dioxide and for soil carbonates, and of the Michigan and Illinois stations for the field testing of the available phosphate content of the soil.

Apparatus for soil sampling, including an improved sampling tube with accessories for driving and for withdrawing the instrument, was devised by the California station. Some experiments with a simple, rapid method for determining the moisture equivalent of soils, and some on the part played by the soil colloids in fixing the value of this constant were reported by the Michigan station. The California station made a critical study of the means previously proposed for the determination of the suction forces of the soil; and at the same station the dispersion of soils for mechanical analysis by means of hydrogen peroxide and hydrochloric acid was compared with the rubbing of the soil in dilute ammonia. The results of the last-named investigation suggested such differences among soils as would appear to make advisable the use, according to soil conditions, of a variety of methods.

Among adaptations of bacteriological technic, one of the more striking was the use made by the Idaho station of certain dyes to eliminate two of the most persistent contaminants of cultures of the nitrite-oxidizing organism by a process of selective inhibition. At the New Jersey stations the use of a dextrin-nitrate-agar medium showed itself capable of facilitating the isolation of *Azotobacter chroococcum*.

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FIELD CROPS

Agronomic investigations at the experiment stations continued to rank high among the progressive lines of agricultural research. Results of these activities include better varieties of cereals, forage plants, root crops, and vegetables, more efficient cultural methods and field practices, a broader

knowledge of the fertilizer needs of crop plants and suitable ways to supply them, and successful means for weed control.

CROP IMPROVEMENT

Corn.—Corn, the most important cereal in the country, received much attention from plant breeders. The Iowa station, cooperating with the United States Department of Agriculture and a local agency, in extensive regional tests of locally improved varieties and hybrids, found that the high-yielding strains nearly always were the earlier maturing ones. Most of the hybrids of unusual value were produced by crossing strains of corn self-fertilized for several generations, usually six or more. Rigid germination tests and the ear-to-row method of breeding, continued for a few years and followed by careful mass selection, had been utilized by most breeders responsible for the high-yielding strains. Heredity, in general, seemed to be a factor somewhat more important than adaptation to a particular soil or locality. The Iowa station, in further cooperation with the Department of Agriculture, observed in different inbred lines marked differences in prepotency for practically all of a number of characters studied. The high-yielding crosses occurred very definitely among the crosses by certain outstanding parent lines. A number of seed, seedling, and plant defects were not correlated significantly with yield in a commercial corn variety.

Ability of corn to withstand lodging, the Minnesota station observed, depended to a considerable extent on inherited differences. Among other recessive defects the Iowa station found a type of lodging due to weak culms. Various aberrations in plant and ear characters were reported on after intensive studies by the New York Cornell, Minnesota, and Texas stations. The Indiana station found that vitamin A was transmitted exclusively with yellow endosperm in the process of crossing and segregation.

Continuous selection by the Illinois station during nearly 30 years for protein and oil content produced four types of corn differing distinctly in their composition. The high oil strain averaged 11.25 per cent of oil and the low oil strain 1.29, while the high protein strain averaged 18.25 per cent of protein and the low protein strain 6.82. In tracing the effect of seed maturity on corn yields, this station

found that the field stand was the prime factor influencing yield. It also observed that certain strains of corn responding to phosphatic fertilization were not as susceptible to disease as strains without such response.

Working with Reid Yellow Dent corn, the Iowa station obtained the best yields from the longer and heavier ears, ears with 16 rows of kernels, medium to wide, dense, horny kernels, medium to smooth indentation, relatively large kernels, and ears fully mature and cured normally. The Texas station did not find number of seminal roots of value as a criterion for selection of productive seed ears.

Small grain.—Yield, milling and baking qualities, and resistance to drought and disease have been the aims in improvement of small grain. The Arizona station in a prolonged study of improvement and adaptation of wheat varieties and strains were grown and maintain high-yielding hard white wheat varieties under irrigation in southern Arizona. Many of the selections were also high in baking quality. The serological ranking of wheat varieties and strains were found by the North Dakota station to be paralleled somewhat by the genetic characters for which the wheats were selected originally. Wheat varieties having the most genetic factors in common showed the closest relationships serologically. Analyzing the yield of certain common and durum wheats, this station observed that in the breeding of new varieties careful attention must be paid to prolificacy, i. e., the number of kernels per head.

The Utah and Minnesota stations reported on the correlated inheritance of a number of important characters in wheat hybrids. The inheritance of characters and their possible linkage relations were investigated in barley by the Colorado and the North Dakota stations and in oats by the West Virginia station.

Cotton.—The demand for cotton characterized by earliness, higher yield, longer lint, and disease resistance proved a stimulus to plant breeders of the southern experiment stations. Several stations brought forth improved strains having one or more desirable features and supplied much information in regard to the genetics of cotton. Inheritance studies at the Arkansas, Florida, Mississippi, North Carolina, Oklahoma, and Texas stations dealt with fiber length, cov-

ered v. naked seed, leaf shape, plant color, the behavior of a number of plant, flower, boll, and lint characters, and also various recessive defects.

Potatoes.—Investigating potato-breeding methods, the Minnesota station found that crossing the earliest available fertile seedlings with the early varieties and selecting from later generations derived from these crosses permitted the isolation of lines combining relatively high fertility with earliness equal to that of the progeny from the early varieties. Indications were that a high yield probably could be obtained upon recombining the inbred lines even without selection for high yield. The Illinois station recorded the behavior of additional characters in the soybean and confirmed the merits of the Illini soybean in the State.

Irradiation of crop plants.—The X-ray treatment of the reproductive organs and the seed of crop plants in endeavors to induce variations produced results of more than passing interest. Germinating seeds of barley, X-rayed at the Missouri station, gave rise to a number of mutants, largely seedling characters of chlorophyll defects. Several mutants were also induced by treatment with radium. X-ray treatment also resulted in greater frequency of chromosome aberration in corn. In both oats and wheat species, the mutation frequency evidently decreased sharply with the increasing number of chromosomes. X-ray treatment of seed tubers of potatoes at the New Jersey stations favored increase in size of tuber in the resulting crop. Abnormalities in cytological behavior, external morphology, and fertility were induced at the California station in different species of tobacco (*Nicotiana*) by radiation with X rays and radium.

These are examples of the current trend in improvement and genetic research with crop plants at the stations.

CROP NUTRITION

The fertilizer needs of tobacco, potatoes, cotton, forage crops, and cereals were subjects of extensive investigation.

Tobacco.—The Connecticut Tobacco substation demonstrated the need of an adequate supply of potassium for tobacco and the injury to the burn and other qualities resulting from reductions of potash below 200 pounds per acre. Best results came from a combination which derived one-third

of its potash from potassium sulphate, potassium carbonate, and potassium nitrate, respectively. When the nitrogen carriers sodium nitrate and calcium nitrate were used high-quality tobacco resulted, whereas liming distinctly reduced fire-holding capacity and percentage of ash. However, tobacco made increased growth on very acid soils, i. e., soils with a pH value below 4.8, when lime supplemented a complete fertilizer treatment in the greenhouse. In the field on a very acid soil producing poor tobacco even when liberally fertilized, tobacco was improved considerably by lime and superphosphate. It was evident that one-half of the nitrogen of the formula could be derived from urea, which had certain other merits. Green manures increased yields and improved grades.

Trials by the Connecticut Tobacco substation, in cooperation with the Department of Agriculture, showed that if magnesia deficiency in the soil is not rectified by the fertilizer both yield and quality of cured leaf may be greatly depressed. The quantity of magnesia taken up by tobacco was influenced by the quantity applied to the soil. Both chlorine and magnesia increased yields to a certain extent. No great differences were noted in quality, yet the poorest tobacco came from control plats where neither magnesia, sulphur, nor chlorine were supplied. Chlorine nearly destroyed the fire-holding capacity of the cured leaf, whereas sulphur or magnesia were not obnoxious in this respect.

Fertilizer trials at the Massachusetts station indicated that on land which, although well fertilized, produces poor tobacco rather heavy applications of superphosphate will improve the yield and quality of tobacco. Of many inorganic and organic forms of nitrogen, the nitrate appeared to be the most readily assimilated by Havana tobacco and produced the best quality. The nitrate evidently tended to counteract the so-called brown root rot of Havana tobacco.

The Pennsylvania station found, in cooperation with the Department of Agriculture, that the beneficial effect of potassium on the burning qualities of tobacco is due to a number of factors, one being its state of combination within the plant. Fertilization and other factors tend to modify this condition. Evidence of a close relationship between potassium and iron on the process of cigar combustion was obtained. Plants grown with manure

alone were consistently inferior in yield and quality to plants produced by manure supplemented with commercial fertilizers. Indeed, high yields of good-quality tobacco resulted from treatment with commercial fertilizer without manure. This station observed that the composition of tobacco leaves may be affected materially by locality, weather conditions, and fertilizer treatment, and that, in turn, the chemical composition affects their burning quality.

The chlorine content of tobacco fertilized with potassium chloride by the Kentucky station was almost in direct proportion to the quantity of chlorine applied in the fertilizer up to and including 400 pounds per acre. Potassium-sulphate applications had little effect on the chlorine content, although the percentage of sulphur rose with increasing applications, although much less rapidly than that of chlorine.

On the basis of their extensive fertilizer experiments the Virginia, North Carolina, South Carolina, and Georgia stations and the Department of Agriculture united in recommending in 1929 for bright flue-cured tobacco on the heavy or more productive soils fertilizer mixtures (8-3-5) containing 8 per cent of available phosphoric acid, 3 per cent of ammonia, and 5 per cent of potash, with an 8-3-3 fertilizer on gray soils with red subsoils of the Cecil series of Virginia, and for light or less productive soils an 8-4-6 mixture. Where sand drown, i. e., magnesia hunger prevails it was recommended that fertilizers carry 2 per cent of magnesia. The nutrients were to come from certain approved carriers, with the specification that the mixtures should contain a maximum of 2 per cent of chlorine. The mixture indicated should be applied at the rate of 800 to 1,200 pounds in the drill before transplanting. For dark tobacco from 600 to 1,000 pounds per acre of an 8-3-3 mixture was to be applied in the drill or just before transplanting.

Potatoes.—Comparing concentrated and ordinary high-grade fertilizers for potatoes, in cooperation with the Department of Agriculture, the Maine station found that the use of concentrated fertilizers under Aroostook County conditions appeared to be well justified, provided the mixture has a good physical condition so that it can be drilled uniformly and be well mixed with the soil before sets are planted. It was observed that difficulty experienced in distributing certain mixtures

uniformly, due to poor physical condition caused by readily deliquescent salts, could be overcome by including a small proportion of cottonseed meal or other organic material for a conditioner. Such conditioner was not needed when potassium nitrate, ammonium chloride, and ammonium phosphate were used. Equivalent quantities of ordinary and of quadruple strength fertilizers applied to potatoes by the New Hampshire station were similar as to resultant yields, and the concentrated material was not injurious. Maryland station findings were similar in regard to double strength fertilizers compared with regular mixtures.

Scattering the fertilizer for potatoes in the row with the sets in New Hampshire station tests appeared to be superior to placement above, below, or beside the seed. Deferring application of the soluble mineral part of the fertilizer mixture until first cultivation was followed at the Maryland station by reduced yields.

Potatoes deprived of potassium and unmanured at the Ohio station were abnormal in growth and coloration and produced small tubers and died prematurely, with characteristic abscission of the lower leaves. Analyses of the tops of such plants disclosed an accumulation of soluble sugar and a deficit of hydrolyzable polysaccharides. Qualitatively, the carbohydrates seemed to be normal. In the growing plant the conversion of soluble sugar to polysaccharides appeared to be hindered by the lack of potassium, and, as a result of the accumulation of sugar, glucosidal pigment was produced in abnormal quantity, and presumably normal photosynthesis was retarded.

Applications of potassium seemed necessary in Maryland station trials for maximum yields on the Norfolk sandy loam, and either potassium sulphate or chloride appeared preferable to manure salts. The Florida station found that potatoes made as good yields with potassium chloride as with potassium sulphate without appreciable difference in the starch content of the tubers. Potatoes at the New Hampshire station returned increased yields with the higher percentages of potassium in the fertilizer and with the heavier applications of manure.

Sweetpotatoes.—A definite interrelationship was observed by the Virginia Truck station between the amounts of rainfall during the growing season

and the relative effectiveness of large quantities of potassium in the fertilizer mixtures. A high potash to a low phosphoric acid and ammonia ratio proved most effective in the formulas. The percentage composition of the fertilizer did not seem to be related to the losses by rot and shrinkage in storage. Character of vine growth was affected more markedly by differences in the nitrogen content than by the phosphorus or potassium content, the higher percentages of nitrogen giving the larger leaves and luxuriant vines. A mixture recommended for the Jersey type of sweetpotatoes on moderately fertile soils furnishes about 30 pounds of ammonia, 30 pounds of phosphoric acid, and 150 pounds of potash.

In experiments on Norfolk sandy loam, the Maryland station found that the soluble-nitrogen carriers used in a complete fertilizer produced the highest average yields of prime sweetpotatoes, and the 60 : 40 per cent ratio led the inorganic : organic combinations. More prime sweetpotatoes were made with potassium than without, potassium sulphate, potassium chloride, and manure salts ranking in effectiveness in the order named. A green-manure cover crop in the rotation in conjunction with fertilizers appeared responsible for significant yield increases.

Cotton.—Cooperative fertilizer trials carried on by the South Carolina station again indicated that even with a systematic rotation liberal quantities of commercial fertilizer may be applied profitably to cotton. Comparing side applications, cotton responded markedly to nitrogen, although phosphorus and potassium also served to increase the average yield considerably. The Alabama station reported on the response of variations of a standard complete fertilizer to meet the needs of cotton on different soil types. The Georgia, Arkansas, Mississippi, and North Carolina stations variously reported on comparisons of carriers of nitrogen, phosphorus, and potassium, and rates and methods of applications and treatments for different soil types.

Corn.—The advisability of combining for corn, hill applications of fertilizers with broadcast fertilizer or manure, especially on light-colored soils low to medium in fertility, was shown by the Ohio station. Hill applications seem best adapted to supply the nutrient needs of corn early in growth, while

broadcast applications provide the later needs. The development and maturity of the crop also were hastened by hill applications.

The South Carolina station found that corn yields were almost directly proportionate to the nitrogen supplied, little response coming from phosphorus and potassium, especially where they had been applied to previous crops. Higher yields came from 200 pounds of sodium nitrate applied when the corn was about knee-high than at other growth stages. Corn yields increased decidedly after legume winter cover crops, especially Austrian Winter field peas, and particularly when side dressed with ammonium sulphate. The Georgia Coastal Plain station found potassium to be valuable for corn on coastal-plain soils and observed that fertilizer evidently should be applied as a side dressing; on very poor soils at least half might be furnished at planting.

Small grain.—Oats at the Georgia Coastal Plain station responded to liberal applications of superphosphate and green manure, and plenty of potassium increased yields and prevented lodging, and profitable increases came from nitrogen supplied early in February. Early spring top-dressing of oats with nitrogen was found quite necessary by the South Carolina station. While increases in wheat yields usually produced by nitrogen were not nearly so large as those in oats, superphosphate and complete fertilizer at planting were of greater benefit. The Ohio station found spring applications of sodium nitrate to be more profitable than fall applications in supplementing phosphorus and potassium for wheat. When applied through the fertilizer attachment of the grain drill at seeding, fertilizer made a larger increase in wheat yield than when applied separately before seeding.

With rice the Texas station found the maximum and most profitable yields to result from application of 100 pounds of ammonium sulphate, preferably added at planting. The Arkansas station found a number of nitrogen carriers adapted for rice production, although ammonium compounds, as ammonium sulphate and ammonium phosphate, appeared better, because rice seemed to be affected less by the changes they produce and less nitrogen was lost by denitrification.

Forage.—Pasture vegetation at the Massachusetts station was changed by

top-dressings of lime, superphosphate, and potassium chloride, a weedy growth of cinquefoil and moss being replaced with white clover, bluegrass, and redtop. Fertilizers also brought about complete changes in lawn grasses. Bents did best when given acid nitrogen with phosphoric acid, fescues thrived when getting acid nitrogen alone, and weed competition was too great for bluegrasses receiving alkaline nitrogen with phosphoric acid and potassium.

The Florida station observed that the protein content of pasture grass when grazed can be increased and maintained at a somewhat higher level than usual by frequent light applications of a nitrogenous fertilizer. The yield appeared to follow the rainfall, and increasingly when nitrogen was supplied. The total nitrogen was higher in the grass when nitrogen was plentiful in the soil and was also high at periods of low rainfall.

Grass on neglected hay lands in New Hampshire station studies responded noticeably to 100-pound applications of sodium nitrate, especially when unmanured, and to lime. With alfalfa, potassium alone was the only nutrient giving increases in hay yields for two cuttings worth more than its cost.

CROP SEQUENCE

The effect of a crop on crops following it in rotation was a promising subject of inquiry. Rotation experiments conducted by the Virginia station showed that corn depressed subsequent crops more than did any of the other crops grown. Small grains did not appear to differ in their effects, nor did cowpeas and soybeans differ materially when properly inoculated. The Virginia, North Carolina, and South Carolina stations all found rotations, especially those including legumes, and fertilizer treatments mutually profitable in the production of field crops.

Effect of sorghum.—Several stations investigated the injurious after effects of sorghum. Barley yields in field trials at the California station were depressed progressively after millet, corn, broomcorn, and sorgo (sweet sorghum) below the yield after fallow, whereas on all plats previously in crop, fenugreek grew normally and yielded higher than after fallow. Relationships were shown between the depression of nitrates by sorghum roots and by equivalent sucrose, and

likewise between barley yields and nitrates thus depressed. The practically normal growth of alfalfa and fenugreek after sorghums seemed to suggest that planting a legume may be the best way to avoid the adverse effects of sorghum. New York Cornell station results suggested that the injurious after effects of sorghum may be associated with the comparative ease with which its roots are oxidized in soil, which process being accompanied by an increase in number of soil organisms and in assimilation of nitrate nitrogen would tend to deplete the available nitrogen. The extent of these processes in the soil when young plants need nitrogen may determine the degree of injury which sorghum exerts on following crops.

Crops preceding tobacco.—The effects of other crops on tobacco, as observed by the Department of Agriculture in Maryland, Connecticut, and Massachusetts, and by the Ohio, Connecticut, and Massachusetts stations were summarized by the Massachusetts station. Certain crops in rotation appeared to depress tobacco, while others seemed to be indifferent. However, those producing notable increases in yield and quality were quite rare. The rotation of tobacco, wheat, and red clover gave very satisfactory returns in Maryland and Ohio, whereas a similar rotation of tobacco, corn, and timothy or clover hay seriously decreased the yield and quality of the tobacco in Massachusetts. The way different crops affected tobacco in different sections was not consistent. Results with cover crops resembled those where different crops are grown in rotation, although cover crops did not give returns justifying their use. Crop effects were found to be associated with brown root rot. In New England in particular the most serious injury from previous crops has accompanied severe brown root rot; where brown root rot was not severe crop effects have been less marked.

CULTURAL PRACTICES

Research concerned with cultural methods and field practices, as usual, developed information of practical as well as fundamental value.

Corn.—In comparison of tillage methods the Nebraska station found that higher corn yields came from early spring plowing, and that the best listing practices yielded slightly less than the best surface-planting practice on plowed ground. Corn planted in

hills and in drills made similar yields, provided the stands were comparable. The planting rate could vary somewhat without affecting very materially the grain yield per acre. Yields rose regularly up to four cultivations, and corn merely hoed to kill weeds yielded somewhat less than that cultivated four times. The type of tillage treatment did not seem related to the reduction of soil moisture during the growing season.

All sorts of corn tended to drop in yield with delayed planting at the Ohio station, and the moisture content at husking of late-planted corn generally exceeded that in corn planted normally. Corn poor because of unfavorable fertility, drainage, or climate showed a rather low infestation with European corn borer, whereas early, vigorously growing corn appeared to present conditions favoring borer accumulation.

Both variety and locality seemed to affect the amount of suckering of corn at the Arkansas station. Deep planting caused an increase, and more stalks per hill caused reductions, whereas neither size of seed nor the soil's content of moisture or available nitrogen appeared to affect the rate. Removal of suckers, especially when of some size, reduced the corn yield.

Removal of blades of corn, in simulated-hail studies by the Illinois station, depressed corn yields severely, especially if done during the early silk stage. Likewise, quality of corn was markedly reduced by removal of blades, particularly after the corn was in the early dent stage or when the silks were brown on from 56 to 70 per cent of the plants. Cutting off the outer half or sections or slitting the blade or breaking the midrib all caused reduced yields. The South Dakota station found that removing all developed leaf blades from corn at any growth period always noticeably depressed grain production, the greatest decrease occurring when leaf blades were taken off at a stage termed tasseling to kernel formation.

The Wisconsin station found that in drying seed corn, temperatures as high as 120° F. may be used safely, regardless of the initial moisture content. In commercial practice the most economical temperature is from 100 to 110°. Corn dried rapidly, as compared with that dried more slowly, was not injured in germination, seedling growth, or maturation.

Small grain.—Furrow-drilled winter wheat outyielded seedlings made with

the common drill at the Wyoming station. Subsoiling, plowing, listing, and disking had about equal effect on land continuously cropped to winter wheat and on winter wheat seeded in the stubble of other small grains. Plowed winter-wheat stubble averaged about the same as that unplowed. The Northern Montana substitution found that the time of plowing summer fallow for wheat is very important and that when land is plowed early enough in the spring previous cultivation of the stubble is unnecessary. Duck-foot summer fallow was very effective, nearly equaling plowed summer fallow for yield.

The percentages of winterkilling of winter wheat, the Wisconsin station found, varied with the planting date. Within a wide range, sudden temperature changes affected the subsequent recovery of the plant, the temperature at which the plant grew before freezing seeming important in this respect.

Grazing winter wheat up to April 1 at the Oklahoma Panhandle station did not affect tillering, delay maturity, or reduce yield, whereas wheat grazed 25 days longer produced fewer heads per plant and considerably less grain, although the time of maturity was similar. While a safe pasturing period would lie between April 1 and April 15, the growth of the plant was deemed the best index. It did not seem advisable to attempt reduction of stinking smut by late grazing, since only a slight decrease is possible and the loss in yield more than offsets the gain in grade of wheat. Comparisons by the Kansas station of different methods of pasturing winter wheat with horses showed that the moderate pasturing of a heavy growth is not injurious and may prove beneficial to the wheat. Where the growth is limited, pasturing generally results in reduced wheat yields. In seasons of drought and slow fall growth, wheat pasture is not dependable as a feed supply for livestock.

Flax-cereal mixtures.—Cooperating with the Department of Agriculture, the Minnesota, North Dakota, Montana, South Dakota, Wisconsin, and Ohio stations found that with rainfall and other weather conditions favorable, a somewhat higher relative yield per acre was obtainable from flax cropped in mixture with wheat, oats, or barley than from the two crops grown separately. Adequate soil moisture during the entire growing season favored a higher relative yield of the

mixed crop as compared with the same crops grown alone. Yields from the mixed crops were about the same under droughty conditions as yields from the crops grown separately. The quality of the flax and wheat in the mixed crop equaled or exceeded that of the crops grown separately. The control of weeds is probably the chief advantage of the mixed crop, which makes possible flax culture on land too weedy for flax alone. Mixed cropping evidently had little effect on the prevalence of leaf rust or stem rust of wheat. Observations were that the mixed crops of flax and wheat and flax and oats were more easily handled in harvesting, shocking, and threshing than flax grown alone.

Grain sorghums.—The Texas station found that milo, which is profusely tillering, averaged about 21 per cent more grain per acre when planted from 18 to 36 inches apart in the row than 3 to 9 inches apart, whereas kafir, sparsely tillering, yielded 13 per cent more grain at the narrower than at the wider spacing, the different response appearing due to the marked variance in tillering habits.

The California station observed that cutting grain-sorghum roots at from 5 to 7 inches below the soil surface to sever the plant from the moisture supply caused rapid drying of the grain, stalks, and leaves in dry fall weather, so that combining may often follow safely in about 10 days. Special attention to varieties and to spacing of rows was found to be necessary.

Dry-land crops.—In prolonged experiments under dry-land conditions, the New Mexico station, cooperating with the Department of Agriculture, found that field crops on fall-plowed land well supplied with moisture in the fall usually surpassed those on spring plowing. However, with the soil dry in the fall, spring plowing was advisable instead. Fallow did not pay in comparison with the better adapted crop rotations, nor were subsoiling or deep tillage profitable. The better listing methods compared favorably with plowing when cost was considered. Many of the other States west of the Missouri River, cooperating with the Department of Agriculture, are carrying on extensive experiments at the stations and substations in crop production under dry-land and irrigation conditions.

Cotton.—Cultivated cotton at the Georgia station made slightly less seed

cotton per acre than that uncultivated but hoed, suggesting that cultivation, while needed to kill weeds, should be as shallow as possible. The South Carolina station over an extended period found that for different varieties and fertility conditions closely spaced plants produced larger yields under boll-weevil conditions than those given abundant space. The partial crowding served to suppress vegetative growth and to promote fruit production early in the season. Closely spaced cotton also was outstanding in Georgia and North Carolina station experiments.

The Arkansas station observed that earliness and total production are affected by the stand more in some years than in others, thus making stands thicker than the normal seem desirable. The stand in rows having two or three plants a hoe width apart or slightly thicker was best from year to year.

Studying the fruiting habit of the cotton plant, the South Carolina station observed that cotton varieties differed markedly in flower production and also in ability to bear a large percentage of their flowers early in the season. Those tending to produce many flowers early bore relatively few late in the season, and vice versa. Slightly less than half of the flowers developed into mature bolls. A much larger percentage of flowers borne early in the season produced bolls than did those appearing later, and there were varietal differences here and in ability to retain squares and young bolls. The fruiting of average plants of each variety showed that few upper branches bore flowers and fewer still produced bolls.

Relative earliness of appearance of first flower, earliness of first open boll, and especially flowering interval in days, and mean boll period determined largely (74 per cent) the earliness of crop, as measured by percentage of total yield obtained at first picking. It appeared that the size of boll and higher lint percentage may give a distinct advantage to a cotton developing fewer bolls. The maturation period of the boll varied with seasons and also within the same season and was prolonged progressively as the season advanced.

Potatoes.—The Ohio station found that the greater number of sprouts per set in potatoes came from delay in planting, maturity of tuber, and wilting of tuber, and also thiourea treat-

ment, whereas certain other factors were of slight effect or ineffective. Immature seed gave more vigorous sprouts, although slower growing, and usually outyielded mature seed. The Alaska stations observed that potatoes from storage developed sprouts more slowly in strong sunlight than in subdued light, and that length of sprout beyond 0.25 inch had little effect on time of blooming or yield.

Seed productivity was found by the Nebraska station to be improved by mulching, late planting, and early harvesting, whereas irrigation and nitrate content of the soil were negligible factors. Early planting, straw mulching, and irrigation all increased the current crop yield. Soil temperatures and also soil texture influenced the shape and appearance of Triumph seed tubers, but like soil moisture did not have significant effects on their productivity. Treatment of sets with thiourea after cutting increased the number of stems and tubers per plant but resulted in a general decrease in tuber size. The optimum strength of solution was in the range 0.5 to 1 per cent.

FORAGE PRODUCTION

Prominent among the forage-research activities reported during the year were alfalfa-production practices, inoculation studies, pasture maintenance and improvement, and lawn studies.

Alfalfa.—Reduction in alfalfa stands in Arkansas station studies seemed due to direct killing of plants by low temperature, by freezing as a result of rapidly fluctuating temperatures, or by partial freezing and subsequent fungal and bacterial invasion of the root and crown system. While neither variety nor treatments so far employed entirely met the stand problem, it appeared that, besides supplying the needs of alfalfa, a hardy variety, liberal manuring, and cutting in advanced-development stages may be the best methods for prolonging the stands.

Potassium and phosphorus fertilizers which were applied to alfalfa by the Wisconsin station greatly increased its ability to withstand winterkilling. The yields rose with increase in potassium applications, which were profitable up to about 300 pounds of potash per acre, and this alfalfa showed a minimum of winterkilling compared with that treated with other commercial fertilizers or manure.

Varietal differences in the persistence of stands of alfalfa were observed at the Kansas station. Evidence that the loss in stand in alfalfa cut often was due to bacterial wilt suggested a relation between frequency of cutting and the onset of the disease. Alfalfa cut in full bloom throughout the season produced the most grass-free hay, whereas stands grew poorer on areas cut continually in the bud stage. Barnyard manure, together with freedom from weeds, was effective at the Oregon station in reestablishment of alfalfa declining in yield because of winterkilling, weeds, and continuous cropping.

The Kansas station observed that when alfalfa was on the land for long periods the moisture of the deep subsoil was reduced to a low percentage and remained almost constant. With most of the rainfall coming during the growing season, the moisture penetrated very slightly below 6 feet and was used by the crop about as fast as it came. At least a short period of fallow is suggested to conserve moisture for starting alfalfa. The Nebraska station also found that alfalfa down for long periods drew heavily on the subsoil moisture, yields during the later years of the stand being curtailed by depletion of subsoil moisture. During the 15 years that an established upland alfalfa meadow was cropped to grain after being broken up, little moisture accumulated beyond the seventh foot, the increase in moisture from the 5 to the 35 foot level averaging 0.4 per cent. At this rate nearly 225 years would be needed to restore the subsoil moisture removed by six years of growing alfalfa. On this account alfalfa may be handicapped greatly on land at some time previously in this crop.

The Ohio station found that, except in northeastern Ohio, alfalfa should be cut at least three times per season, i. e., the last cutting early enough so that the crop may enter the winter with a healthy, vigorous growth 10 to 12 inches high, and the first cutting usually at a somewhat earlier stage than the second or third. The slowing up or cessation of vegetative growth and stage of bloom were the best indications that alfalfa was ready to cut. The more mature alfalfa became before cutting at the Oregon station the higher was the yield obtained during the year, although the quality of hay cut beyond rather full bloom was questioned.

Curing experiments with alfalfa hay conducted by the Iowa station showed that the leaves aid in drying the stems, being more effective in the windrow. Production of the best hay, normally obtained by windrowing soon after cutting, could be hastened somewhat by partial drying in the swath before windrowing.

Either no clipping or clipping not later than the start of blooming was best for production of alfalfa seed at the alfalfa-seed farm of the Utah station. Cultivation was for weed control and resulted in a higher purity of the seed produced. So far the type of cultivation did not influence greatly the seed yield, which was highest on unirrigated plats.

Inoculation.—The beneficial effect of liming for establishing thorough inoculation of legumes on acid soils, according to Missouri station studies, may be due partly to the calcium as well as to a change in degree of acidity. The Illinois station observed that one part of a field may have plenty of active nodule bacteria, while a more acid area may lack the organisms, and also that even though the nodule-forming bacteria of a certain legume produced nodules upon a second legume, the organisms of the latter may not necessarily infect the first legume. That the value of soybeans for soil improvement is not limited to the nitrogen added through their nitrogen-fixing bacteria was confirmed. Soybeans affected the distribution of soil microorganisms and increased their numbers and activities.

Wide differences were found by the Wisconsin station in the stimulation which clover received from symbiosis, although root nodules were produced by all the strains of clover bacteria. The kind and location of nodules on the roots seemed to be correlated with the benefit the plant derived. The best strains gave relatively few but larger nodules located near the top of the root system, while the poorer strains produced many small nodules scattered over the entire root system. In strongly acid soil the nodule organism was comparatively short-lived, and inoculation was necessary, even though the field had recently produced a good crop of peas.

Some commercial cultures of legume bacteria were found by the Illinois station to be very effective in nodulation and nitrogen fixation, while others were less efficient. No inoculants for nonlegumes justified claims made for

them. The Iowa station observed that a commercial culture for the inoculation of nonlegume crops did not contain large numbers of efficient nitrogen bacteria and did not stimulate the processes occasioned by these organisms in a normal Iowa soil. Tests failed to demonstrate that the culture had a beneficial effect on a number of crops.

Pastures.—In a study of maintenance and improvement of permanent pasture on typical run-down rough land, the Connecticut Storrs station obtained the best response from applications of superphosphate, limestone, and potash and the next best from superphosphate with limestone. Both of these combinations increased the content of white clover. Worn-out old-field pasture lands seeded by the Virginia station to mixtures of tame grasses produced fair to excellent stands, persisting strikingly under heavy grazing through protracted summer drought. Such pastures furnished grazing much earlier in the spring and later in the fall and were more palatable to cattle than broom sedge and other native grasses. Soil erosion was arrested by the general treatment.

Grazing fertile bluegrass pastures heavily, closely, and prematurely at the Wisconsin station did not permit storage of adequate organic nutrients in the roots and rhizomes, and as a consequence the amount of underground growth was so limited that white grubs devoured all the roots. In establishing sweetclover in bluegrass pastures, this station demonstrated the need of removing accumulations of old grass by burning or otherwise to permit legume seed to reach the soil. It further observed that pasture yields can be doubled by adding enough lime, nitrogen, phosphorus, and potassium. The quickest response came from manure, and re-seeding of 5 pounds of white clover per acre with the manure was the most efficient method tested, although a complete commercial fertilizer was nearly as good.

The Hohenheim system of permanent pasture management, recently developed in Europe and tested by several stations, comprises the division of a pasture into several paddocks, rotation of grazing from one paddock to another, and top-dressing the grass with a nitrogenous fertilizer at intervals during the season. With a mixed bluegrass and redtop sod, the Ohio

station found grass very efficient in utilizing fertilizer nitrogen in producing both dry matter and protein, the yields of each being closely related to the time, frequency, and quantity of the applications. The Massachusetts station, obtaining similar results with the system, found that a thick sod is essential for best results from fertilizers.

The Oregon station in field studies demonstrated that pasture establishment to be economical should be done by fall seeding on a good first burn. For permanency and to resist encroachment from brush, the pasture mixture must include sod formers, and the land must be kept grazed. Many loggings were damaged irreparably by losing the long-time effects of a first burn as a result of sowing cheap and temporary burn mixtures. Unseeded, burned-over land or land seeded to temporary burn mixtures soon returned to brush.

The West Virginia station found that broom sedge and poverty grass, in common with other pasture grasses, were relatively high in protein and low in fiber early in growth, as compared with later stages. Best utilization of their pasturage involved reasonably early, close, and continuous grazing during spring and early summer. Removal of the old growth of broom sedge before new growth appears permits better grazing of the new growth.

Lawns.—Lawn clippings left on the ground at the Ohio station were found to benefit the grass; the grass was decidedly darker green in color and more luxuriant in growth than where clippings were removed. Cutting late in the fall seemed to injure the lawns.

Fertilizers applied to lawns by the Rhode Island station resulted in healthy turf and a wide range in soil reaction. The bent grasses seemed to be particularly tolerant to acid soil reaction. Red fescue and fine-leaved fescue were very durable under either acid or alkaline conditions, whereas redtop and crested dogstail were short-lived. Kentucky bluegrass did not persist so well as acclimated bents, especially with relatively high soil acidity. Weeds were fewer as the acidity increased. The Connecticut State station found that top-dressing with readily available nitrogen was the prime need for average lawn turf.

The Florida station found that while fertilizers tending to make the soil more acid did not control weeds in lawn grass, a mixture of aluminum

sulphate, iron sulphate, and sand destroyed the weeds and seemed beneficial to the grasses. St. Augustine and centipede grasses were outstanding for lawns, and Italian ryegrass, redtop, and Kentucky bluegrass were promising for winter lawns.

CROP QUALITY

Recent trends toward the production of crops having particular outstanding characteristics, as better fiber in fiber crops, quality in tobacco and sugar crops, and enhanced protein content indicative of bread-making quality in wheat, were evident in agronomic research reported during the year.

Fiber crops.—Technological studies carried out by the Georgia station revealed that for the cotton varieties tested increase in weight per inch of hair (fiber) was accompanied by increase in tensile strength, and that, in general, mature and well-developed hairs were stronger than immature, thin-walled hairs. Weight of hair per unit length increased with progress of maturity from fertilization until the opening of the bolls. Short seed hairs were heavier in proportion to length than long ones, indicating that ordinarily long-staple cottons have finer lint than short staple. The North Carolina station observed that high strength of drag, i. e., resistance overcome in pulling apart a sample of ginned cotton, was not an important factor in yarn strength and in the running quality of cotton.

The Texas station found that most commercial cottons possess a high degree of variability in staple. Varieties differed greatly, although not very consistently, in this character in response to climatic conditions and likewise in production of motes (aborted ovules), which were especially numerous in a dry year. Increases in percentage of motes per plant were accompanied by reduction in size of boll.

The New Mexico station found that cottonseed grown in the State would be among the highest in oil content, above average in protein, and average or less in gossypol. Neither a pronounced seasonal variation nor a correlation with the quantity of irrigation water was observed. Immature seed contained less oil and protein than did mature seed.

The quality of fiber of flax from a ret at pH 7, at the Michigan station, was better than or as good as that from more acid or alkaline ret. Re-

placing the old water once a day was better than replacing it every six hours, since it produced a fiber of better quality, which was less harsh and contained more nature, although it hackled less line fiber.

Tobacco.—The effects of fertilizers and other treatments on the quality and yield of tobacco at the Connecticut Tobacco substation and the Massachusetts, Pennsylvania, Kentucky, and other stations have been discussed above under crop nutrition. In experiments on the culture of high-nicotine tobacco the New York State station found that the nicotine content compared very well with similar tobacco grown in other humid regions, but both yields and nicotine content fell far below those of the same species grown under irrigation in the arid Southwest. Plant selection, fertilization, careful topping, and culture raised the nicotine content to a certain extent, but not strikingly, and season also appeared to be important. It did not seem practical for the New York fruit grower to grow his own tobacco with the expectation of using it for spray purposes.

Sugar crops.—The Arkansas station found that late varieties of sorgo were superior to early sorts for the total production and quality of sirup. The climatic conditions appeared to affect the quality of juice of sugarcane at the Porto Rico Insular station more than did fertilizer treatments. Chicory appeared as good as or better than Jerusalem-artichoke as a source of fructose in Minnesota station studies, seeming to reach its maximum fructose content relatively earlier.

Wheat.—Wheat grown on fallow by the Montana station produced higher yields, and the grain had a higher protein content than continuous wheat. These attributes were further intensified by cultivating the fallow. The fallowed lands contained more moisture and nitrate nitrogen, which were reflected in the higher grain yields and protein content. Several factors influencing the protein content of wheat which appeared largely within the control of the farmer, e. g., good farm practices, such as manuring, rotating wheat with legumes, and clean fallow or summer tillage, give increased yields and produce wheat crops higher in quality as indicated by protein content.

A survey by the North Dakota station revealed that for the State as a whole wheat after cultivated crops

and legumes usually averaged higher in protein content than wheat after small-grain crops. Weed infestation tended to lower protein content. The Kansas station observed that the most notable effect of the cropping system and the fertilizer treatment was on the protein content of wheat, those soil treatments giving a seed bed well supplied with nitrates and producing high-protein wheat. The quality of wheat differed between varieties and also for different seasons for varieties as a group.

Protein content was found by the Michigan station to vary within a variety with the size of grain, being lower in the smaller kernels. The hard kernels contained consistently more protein than the soft kernels, but the relationship was not apparent between protein content of one year and that of the progeny, nor between protein content and breaking pressure. Within a pure line, environment seemed to play an important part in determining the protein content of the white wheats.

WEEDS

Control by chemicals and cultivation, physiological studies fundamental to control measures, records of introductions, and surveys of distribution were major station activities with weeds.

Sodium chlorate was used successfully to control bindweed or wild morning-glory by the Kansas, Oregon, and Washington stations; to control quack grass by the Indiana, Michigan, Ohio, and Oregon stations; and on Canada thistle by the Ohio, Oregon, and Washington stations. The Ohio station also found the chemical effective on oxeye daisy, white snake-root, and lawn weeds, and the Montana and Idaho stations used it successfully on various perennial weeds. The sodium chlorate usually is applied in solutions at times and rates to suit the particular cases. The Kansas station determined that magnesium chlorate and calcium chlorate could substitute for sodium chlorate in bindweed control; they lack the fire hazard of sodium chlorate and are more hygroscopic.

Carbon disulphide applied in holes in the soil of infested areas by the Colorado station killed successfully in a single treatment such perennials as morning-glory and Russian knapweed. The current cost of material and of application limited the use of carbon

disulphide to kill perennial weeds to small areas and very valuable and productive land. The Oregon station found that carbon disulphide under optimum conditions was a good herbicide, but that, as ordinarily applied, it was too expensive and not generally successful.

The Ohio station observed that the percentage of organic food reserves in Canada thistle decreased in the spring during growth, reaching a minimum about June 1. Mowing the thistle, most effective when begun June 1, delayed the storage of food reserves and thereby appeared to cause the death of many of the weaker plants. Mowings made regularly a month apart and continued through four seasons removed practically all the thistles.

Buck brush in pasture lands, the Kansas station found, contained the least starch in both roots and stems about May 15. The time of least quantity of stored food material agreed with the effectiveness of cutting, i. e., cuttings about May 15 were about 75 per cent effective with buck brush, and those about June 15 were about 50 per cent effective with sumac.

Goat grass (*Aegilops* sp.) was observed by the California station to be a serious pest on grazing lands and injurious to livestock. The Kansas station found it was a troublesome weed, especially in continuous wheat, as it seemed to be a host for wheat rust and seriously to dwarf the wheat.

HENRY M. STEECE.

HORTICULTURE

The year 1929 was marked by consistent progress in various fields of horticultural research. An outstanding feature was the publication of papers dealing with fundamental problems in floriculture and pointing to the time when the various lines of horticultural activity will be more nearly equally represented in the field of research. As usual, problems in pomology were the most prominent subjects of investigation.

Fruit-thinning studies.—Unusual interest was manifested in fruit thinning, particularly of the peach, a fruit possessing a strong tendency to annual overproduction. The Illinois station presented further evidence in support of their previous findings that peaches may be thinned up to the time of the final enlargement without material detriment in size of the remaining fruits. At this stage natural dropping had ceased, and various insect and other

injuries were fully manifested, and the selection of the best fruits was thereby greatly facilitated. Thinning was most effective on strong, vigorous trees capable of sizing up their fruit. Working with Elberta peaches, the West Virginia station obtained similar evidence in regard to the practicability of late thinning, and from its results and those of the Illinois station tentatively recommended late thinning as a wise practice for the grower.

A favorable influence of fruit thinning upon the growth of the Lombard plum was noted at the Michigan station. The difference in amount and character of growth in favor of the fruit-thinned trees was so pronounced as to be readily detected by the casual visitor in the orchard, and exact measurements demonstrated that the length and diameter of terminal shoots and of the leaves were significantly greater on the thinned than on the control trees.

Studies at the New Hampshire station with the Baldwin apple showed larger and more highly colored fruits on thinned trees. However, the reduced total yields resulting suggested that thinning of this apple variety is unprofitable.

Removing at an early stage of development a portion of the berries from clusters of vinifera grapes was found at the California station to be highly effective in certain varieties in improving the size and uniformity of the individual berries and in promoting an earlier and more uniform coloration. The berry thinning was recommended for vineyards the fruit of which has been in the past variable in quality and of unsatisfactory color.

Fertilizer studies.—Despite material advancement in recent years in the knowledge of fertilizing horticultural plants, especially fruit trees, there can be no expectation of ever completely solving all of the manifold problems, since soils vary so greatly, even within the limited area of a single orchard. It appears likely, therefore, that the development of definite recommendations of universal application can scarcely be expected, although the general principles may be very well understood. The very important function of nitrogen in the fertilization of orchard trees is now quite well established, but as yet it has not been determined whether nitrogen fertilization in excess is detrimental or not to the keeping quality and color in the fruit. The Pennsylvania station obtained evidence that phosphorus may

become in time a limiting factor in older orchards of the State, principally by its favorable influence on the growth of cover crops and through the cover crop on the supply of organic matter in the soil.

The Arkansas station in a study of the effects of commercial fertilizers on the performance of peach trees noted some gains from phosphorus but concluded that these were too small and inconsistent to be accepted as of significance. In the case of Ben Davis apples grown on a certain Arkansas soil type, phosphorus definitely influenced growth and yield. With the peach nitrogen gave very consistent and marked results in both yield and growth.

That potassium may under certain conditions be of value to peach trees was indicated in preliminary results obtained at the Maryland station, where yields in one experiment were significantly larger with nitrogen and potash in combination than with nitrogen alone. Phosphorus had no apparent effect when used with nitrogen but when used with nitrogen and potassium did give certain increases. Evidently there are certain interrelationships between fertilizer materials that need further investigation.

As respects the time of applying nitrogen fertilizers, the Maryland peach experiments tended to show that applications of sodium nitrate are most effective just before the buds begin to swell in early spring. Of the sources of nitrogen for peach trees, the Maryland experiments suggested that no significant difference existed between sodium nitrate and ammonium sulphate, except in the slower availability of the ammonium sulphate.

At the Illinois station, where sodium nitrate, ammonium sulphate, and calcium cyanamide were applied to 28-year-old Winesap apple trees and the percentage of nitrogen in the spurs was determined, sodium nitrate and ammonium sulphate were found to be equally effective in the case of annually fertilized trees, but calcium cyanamide was too slowly available. The functions of less familiar fertilizing elements, such as boron and magnesium, as yet have not been considered seriously in orchard-fertilizing experiments. There were some indications, however, from laboratory experiments with citrus at the California station and with tomatoes at the Maryland station that a very small but appre-

ciable quantity of boron is essential to plant growth, and the Massachusetts station observed that long-cropped soils may become deficient in magnesium.

Pruning studies.—Despite the fact that problems in pruning of fruit plants are complicated by many related factors, such as fruiting habit, vigor of growth, age of tree, and winter injury, and other environmental causes, experimental horticulturists have in recent years contributed greatly to the solution of these problems. The further need for information on pruning is indicated in the large number of pruning projects under way at the stations; some of these are rather elementary in purpose, while others are decidedly fundamental and concern the underlying relations between pruning and growth and reproduction.

That pruning may materially influence the carbohydrate metabolism of the grape was shown at the California station. In general, decreases in the amount of pruning were correlated with increases in the quantity of carbohydrates in the vine, and since carbohydrates are vitally concerned with fruiting, changes in content are of the greatest significance. A positive correlation was noted between the number of leaves on a vine and the setting of berries and the development of the fruit. A decrease in leaves was accompanied by a decrease in production, lighter weight clusters bearing fewer berries.

The importance of leaf area to fruiting in the apple was shown in studies at the Washington station with leaf-thinned Delicious, Winesap, and Jonathan apple trees. Under normal moisture and growing conditions leaf area was found to largely limit the size and quality of the fruit. From 50 to 75 leaves per fruit were found to be necessary for the development of first-class flavor in the Delicious apple.

That moderate pruning of the red raspberry is beneficial and necessary was shown in Minnesota station studies in which Latham canes were pruned to 15, 36, and 60 inches. The 36-inch plants yielded quite as well as the 60-inch plants and produced larger and finer berries, while the yield of the 15-inch lot was reduced materially.

Breeding investigations.—Breeding and its related problems, such as pollination and sterility, have received important consideration by station horticulturists because of their intimate

relations with the improvement of horticulture. The varieties of the present day must of necessity often give way to improved varieties of the future better adapted to the rigorous climate of North America.

The New Jersey stations continued their investigations in peach breeding, presenting further data on the inheritance of various tree, fruit, and flower characteristics. For example, the transmission of pollen sterility, a characteristic strikingly manifested in the J. H. Hale peach, was found to be influenced by the male as well as the female parent. Peach varieties developed at the New Jersey stations continued to take an important part in the peach-growing industry of that State.

Working with the apple, the New York Cornell station found that within a single variety the vigor of the individual tree exerts an important influence on the potency of the pollen, and that trees of apparently equal vigor may differ widely in their capacity to set fruit when pollinated with the same quality of pollen.

Cytological investigations at the Arkansas station upon selfed and cross-pollinated apple blooms indicated that the average rate of growth of the pollen tube in selfed pistils is definitely slower than in cross-pollinated pistils, and that the number of tubes reaching the locules is much smaller in selfed pistils, offering a satisfactory explanation for self-sterility in the apple. Cessation of growth of the pollen tube was followed by an enlargement of the end both in selfed and crossed blooms but more frequently in the selfed.

The Anjou pear was found by the Oregon station to be practically self-sterile but readily pollinated by Bartlett, Easter Beurre, and other varieties. Anjou blooms were successfully pollinated in cold, rainy weather if the pollen was applied directly to the stigma, suggesting that the usual unfavorable pollination in inclement weather is due to the inability of compatible pollen to reach the stigmas rather than to the direct effect of low temperature.

Propagation studies.—Impending embargoes on fruit and ornamental rootstocks created an unusually keen interest in propagation problems, a situation reflected in a marked increase in the number of projects and of papers dealing with the subject.

The Wisconsin station reported that the scion, especially when grafted directly on the root as in piece-root propagation, exerts a profound influence on the character of the root growth, whereas budded trees and trees which were grafted above the crown had variable roots more like the original seedlings. The Maryland station found that the male parent of apple seedlings had considerable influence on the growth, as measured in height development the first and second years. The male parent also influenced the uniformity of the seedlings, since the several progenies were less variable than the entire lot.

The Tennessee station found that rubber tape could be advantageously substituted for raphia in the tying of buds. The Michigan station found that German peat was an extremely satisfactory medium for rooting blueberry cuttings, but that immersion of the cuttings for 24 hours in such materials as potassium permanganate, acetic acid, and dilute sugar solutions is of little, if any, benefit.

Studies at the Michigan station of various types of graft unions and of the tissues of healed wounds led to the conclusion that the swellings often occurring at the union of stock and scion are not associated with a lack of congeniality. Indeed the largest swellings were often found in congenial grafts.

The Pennsylvania station working with young apple trees growing on vegetative and seminally propagated rootstocks found that trees on the vegetative rootstocks became increasingly uniform, even though at the beginning they were distinctly more variable than the selected commercial stock on seedling roots.

Fruit-handling studies.—Presenting further evidence in long-continued studies on the harvesting, storing, and ripening of pears, the Oregon station reported that pears have a definite storage life beyond which they do not ripen satisfactorily, notwithstanding ideal temperature and humidity conditions. The Bartlett was found to keep from 40 to 50 days, Bosc, Comice, and Seckel 90 to 100 days, Howell 100 to 120 days, Anjou 150 to 180 days, and Winter Nelis 160 to 180 days. A few days at from 65 to 70° F. following removal from cold storage were required to produce prime condition in pears. In studying ripening changes in sweet cherries the Oregon station found that important changes occur

in the weight, size, color, and sugar and solids content during the ripening period, so that time of picking had a very material influence on yield and quality. Tree-ripened cherries reached eastern markets successfully, suggesting the desirability of leaving fruit on the tree until it has developed high quality.

A new system of grading prunes, developed at the Oregon station and based on the flotation principle in solutions of either salt or sugar in which both dried and fresh fruits were successfully separated into various sizes, proved much more accurate in respect to differential quality of the resulting product than the old system of grading by size alone.

Experimental vegetable studies.—The continued expansion of fundamental investigation with vegetables during 1929 demonstrated that horticulturists are appreciating the adaptability of vegetables with their relatively short life cycle and small size of individual plant as material for investigation. Important progress was reported during the year in the breeding of vegetable crops.

In studies of the relation of sex in asparagus to production the California station presented further evidence in favor of male plants. Computed to an acre basis, male Palmetto plants produced nearly 15 per cent more marketable asparagus than did the female plants. The superior productivity of male asparagus was also established at the Massachusetts station.

Extensive studies with various species of cucurbitaceous plants, such as squash, pumpkins, and vegetable marrows, at the Iowa station showed that these species hybridize with extreme difficulty. Of a total of more than 3,000 pollinations, including reciprocals, only 3 or 4 fruits with fertile seeds were secured. Within a species varietal crosses were readily accomplished, and the maintenance of pure lines by continued self-pollination was found entirely feasible.

Lettuce-breeding studies at the Illinois station involving crosses among cultivated varieties and between the cultivated varieties and the wild lettuce, *Lactuca scariola*, showed decided dominance of certain characters, such as anthocyanin pigment, black seed color, and prickliness of leaves. The California station determined that the period of receptivity of the stigmas of celery flowers continued for several days, and that fertilization generally did not occur until approxi-

mately eight days after anthesis. The somatic chromosome number in the root tip cells was established as 22.

Physiological studies with vegetables were numerous. In a study by the Maryland station of factors concerned in the premature seed production of cabbage overwintered in the field, the conclusion reached was that the amount of reserve foods stored in the young plant in late autumn was the critical factor in determining seeding behavior. Large plants resulting from unusually favorable autumnal weather were especially inclined to develop premature flower stalks. In a comparable study with celery the New York Cornell station found that cool temperature during the early life of the plants in the seed bed or field is the controlling factor in respect to seed-stalk production. Comparatively low temperatures, 40° to 50° F., when continued for 10 or more days greatly increased the tendency to premature blooming. It was suggested that some specific type of amino acid may result from the continued cool temperature and may possibly be the initiating factor in blossom-bud formation.

The Maryland station reported that under normal cultural conditions temperature is the most potent factor concerned in the development and yield of the pea plant. At higher temperatures a shorter time was required for the pea to reach any given stage of development, and the weight of plant, the weight of the pods, and the number of pods were reduced. Chemically, no significant difference was established between peas ripening in cool and those ripening in hot weather, but the time during which a lot of peas were fit for canning or eating was materially shortened by high temperature.

Dividing the tomato fruit into five portions, the Indiana station found that the outer-wall and inner-wall section was the most valuable part because it contained a higher percentage of dry matter, of insoluble red solids, and of sugars. The higher quality often observed in the early-maturing fruits of tomato plants was believed to be associated with a larger percentage of the desirable outer and inner-wall tissue. The Virginia Truck station found that spinach plants were rather sensitive to acidity reaction of the cultural medium in which they grew, leaf growth attaining a maximum development at pH 5.5 and a minimum at pH 4.

The current idea of a close association between the number and size of the fibrovascular bundles in celery and stringiness was dispelled by the Illinois station, which established that collenchyma was the only tissue associated with stringiness, the causative factor being the hardness of the cell walls. Pithiness was attributed to the breaking down of parenchyma cells, and no bast fibers were found in any of the varieties.

The Virginia Truck station found several of the synthetic nitrogen fertilizers to be effective for spinach when used as top-dressings in complete combinations. When applied on the basis of equal contents of actual nitrogen, the resulting yields resembled those secured with a mixture of sodium nitrate and ammonium sulphate.

At the Maryland station commercial fertilizers replaced manure satisfactorily in fertilizing asparagus in field plats. In controlled sand cultures, however, manure proved highly essential, suggesting that the initial content of organic matter in the soil is an important factor in determining fertilizer requirements.

Floricultural studies.—Significant among the investigations with ornamental plants was the observation of the Ohio station that chrysanthemums thrived under a comparatively wide pH range, 5 to 8.5, within which no material effect was noted on the diameter of bloom or length of stems. Plant selection on the basis of high and low producing parents failed to show any transmission of these characteristics, provided the stock plants were healthy.

The Rhode Island station, working upon the sterility problem in the gladiolus, found several types of sterility in one of which the pollen and ovules were aborted and in another the pollen grains and ovules were apparently perfect but incapable of functioning. The large-flowered garden varieties were generally self-sterile and the primulinus hybrids self-fertile.

A relation between length of day and capacity for winter forcing in the gladiolus was shown in studies at the Illinois station. Corms of the Virginia variety planted in the greenhouse in October bloomed 10 days earlier than and produced more than twice as many blooms under artificial light as did the controls under normal light.

J. W. WELLINGTON.

PLANT DISEASES

Plant-disease investigations by the experiment stations in 1929 were characterized by a revival of interest in certain of the older unsolved problems, notably the control of fire blight in pome fruits and control of scab and Rhizoctonia scurf in the potato. However, substantial progress was also recorded along other lines.

DISEASE-CONTROL STUDIES

Fire blight.—At least three stations—Arkansas, Michigan, and Wisconsin—made valuable contributions to the knowledge of the nature and control of fire blight in pomes. All of these stations concurred in concluding that the tissues immediately surrounding the hold-over cankers on the trunk and branches are the principal overwintering harbors for the organism and, incidentally, that much benefit accrues from the systematic cutting out of these cankers during the dormant season. Apple varieties were rated by the Wisconsin station in regard to their susceptibility to fire blight, and a distinct correlation was shown between susceptibility and the comparative number of hold-over cankers. Each of the stations named above reported that insects and rain are the principal agents concerned in the transfer of the disease, and presented evidence that the pathogene can enter the tissues of healthy leaves through the stomata. The Arkansas station also found that flower tissues could be penetrated in the same manner, fire-blight bacteria progressing through apple-petal tissue by dissolving the cell walls, the contents of which apparently serve as an excellent source of food for the organism. No obligatory relationship was found between blight on the apple and blight on the pear, either fruit being apparently a complete host, although it was noted that the disease usually was more virulent on the pear.

The Oregon station continued work on the breeding of fire-blight-resistant pear stocks, one variety being located which was a potent parent of resistant seedlings. Spraying pear trees with Bordeaux mixture, 3-6-50, just before and after blooming was found by the Oregon station to lessen materially the number of blight infections. The Tennessee station found that *Pyrus calleryana* was a promising blight-resistant pear stock and was also strongly resistant to certain leaf spots which caused serious defoliation injury.

Apple diseases.—At the Wisconsin station liquid lime-sulphur, 1 pint to 40 of water, was found to be the most efficient control for apple scab. Lime-sulphur and Bordeaux mixture proved more adhesive than dusts, oil sprays, or other combinations, and the addition to sulphur dusts of potassium permanganate as an oxidizer did not increase their effectiveness, although potassium permanganate possessed certain fungicidal properties when used alone.

The New York Cornell station found three distinct rust diseases attacking the apple in the Hudson River Valley and designated them as the apple, hawthorn, and quince rusts. The apple and quince rusts were observed to cause direct and serious infections of the fruit, while the hawthorn rust occasionally was injurious to foliage. Eradication of red cedar was found a very important measure in the control of all three rusts.

Calcium sulphide was found by the Virginia station to be highly promising for disease control on varieties of apple and peach whose fruit and foliage are easily injured by certain sprays. Better results were obtained on apples with calcium sulphide than with a customary lime-sulphur Bordeaux-mixture schedule. Calcium sulphide was not, however, effective in the control of bitter rot.

Potato diseases.—That the treatment of seed potatoes to prevent the development and spread of seed-borne diseases has not yet been perfected fully was evident in the number of papers published thereon and the somewhat conflicting results. The Nebraska and Kansas stations, reporting separately, asserted that hot formaldehyde was a highly effective treatment for control of *Rhizoctonia* and scab on seed potatoes. The Wisconsin station, on the other hand, reported the best control with corrosive sublimate. That differences in environmental conditions may have caused the contrary results is suggested in the fact that the Kansas station found the highest efficiency of hot formaldehyde, 1 to 120 strength, in a three to four minute immersion at 124–126° F. With lower temperatures and shorter immersions the effectiveness decreased materially. Fall treatment was as successful as spring treatment and had no effect on the rest period of the tubers.

The Wisconsin station found that germination and early growth of po-

tatoes were stimulated by immersion in solutions of some of the organic-mercury compounds. The New York Cornell station, working on Long Island, obtained increased yields averaging only 2 per cent and suggests that these are too slight to justify the cost of treating potatoes with organic-mercury materials. It is pointed out, however, that in these experiments only the highest grade of certified seed was used.

Addition of organic-mercury disinfectants to the fertilizer applied before planting in tests at the New Jersey stations was quite effective in controlling potato scab but had a deleterious effect on growth and yield.

As determined by the Vermont station, net necrosis in the potato is apparently the initial symptom of leaf-roll infection and was produced experimentally in healthy plants by the transfer by aphids of leaf-roll virus from diseased plants. Tubers showing net necrosis contained larger quantities of lignin, suberin, and pectic substances than did healthy stock.

Miscellaneous diseases.—Dipping sweet-potato plants in Bordeaux mixture or thoroughly dusting them with a copper-sulphur-lime dust just before transplanting was found at the North Carolina station to be highly beneficial in reducing wilt or stem rot, particularly when healthy seed stock was employed. The dipping or dusting of infected plants did not, on the other hand, reduce disease materially. Dipping sweetpotato slips in corrosive sublimate or organic-mercury solutions was found by the New Jersey stations to reduce the proportion of diseased plants in the field.

At the Arizona station spread of cotton root rot in the soil was prevented by treating the soil with solutions of formaldehyde and cresylic acid. Open trenches 20 inches deep were ineffective. The appearance of the fungus on dead roots led to the suggestion that cotton root rot may exist in nature as a saprophyte in the absence of living root tissue.

Finding that vaporized sulphur is effective in control of leaf mold on greenhouse tomatoes, the Massachusetts station perfected an electrically operated device for vaporization of sulphur.

The Wisconsin station found that dead plant tissues, particularly of tobacco, are an important factor in the overwintering of tobacco-mosaic virus and recommends systematic ro-

tations for seed beds and field crops, supplemented by sanitary measures in the handling of crop refuse to prevent transfer of the disease to clean fields.

Applied in single applications at time of seeding, chemicals such as aluminum sulphate, corrosive sublimate, and various organic-mercury compounds, either as liquids or powders, were found by the New York Cornell station to be highly effective in controlling the damping-off of Norway spruce and red and white pine seedlings. Aluminum sulphate cost much less than the mercury compounds.

DISEASE-RESISTANCE STUDIES

Corn.—Investigations by the Iowa station of the resistance of pure lines of corn to smut, *Diplodia*, and *Fusarium* infections revealed marked differences in resistance, even in very closely related strains, and gave promise of the development of resistant varieties. That the structure of the corn plant is an important factor in resistance to smut was evident in the occurrence of 74 per cent infection in plants with open terminal-leaf spirals, as compared with its occurrence in 27.3 per cent of the plants with closed spirals.

Wheat.—An association between the age of the wheat plant and its resistance to disease was observed at the Kansas station, where certain varieties highly susceptible to a given physiologic strain of leaf rust during the seedling stage became strongly resistant at heading time. Other varieties changed very little, if at all, and any variety resistant or rust free in the seedling stage continued resistant throughout its entire existence. Latent resistance of the kind described was found in varieties of wheat representing the most important types for the manufacture of bread flour.

Comparable evidence was obtained by the Minnesota station in studies of the nature of resistance of wheat to stem rust. Young leaves opened their stomata earlier in the morning and kept them open longer than did older leaves. Since the fungus enters the plant through the stomata and since the critical period for infection is in the early morning, younger leaves were obviously more susceptible. It is pointed out that because of this situation varieties ordinarily resistant in the field may be susceptible in the seedling stage. Direct sunlight was the most important of various factors

concerned in the opening of cereal stomata.

Beans.—The Wisconsin station concluded that often it is more practical to purchase bean seed from favorable growing districts than to attempt to breed resistance to certain seed-borne diseases, such as blight, anthracnose, and mosaic.

Cabbage.—Resistance to yellows was found by the Wisconsin station to be dominant to susceptibility and apparently controlled by a single genetic factor. Concerning black rot of cabbage, the results indicated that parent plants showing only little infection may be a potential source of disease through their seeds.

J. W. WELLINGTON.

ECONOMIC ENTOMOLOGY

There was continued advance by the stations in work in economic entomology. Investigation with insecticides, attractants, and repellents as adapted to the control of some of the more important pests was particularly active. Search for effective substitutes for arsenical poisons with a view to solving the residue problem also was actively pressed. Increasing attention was given to the oriental fruit moth, which, although of especial importance as a peach pest, is complicating control work with the codling moth in apples.

Fruit insects.—Codling-moth control continued to be a major subject of investigation. Certain oil sprays and oils combined with other insecticides were found by the Illinois station to be fully as effective as lead arsenate when used as late-brood sprays in combating the codling moth, although they can not be used throughout the year. The Washington station found that the addition of fish oil, a semidrying oil, caused lead arsenate to adhere better to fruit and foliage and to give increased protection to fruit. Lead arsenate in the proportion 1 to 100 and fish oil 0.25 per cent gave as good results as twice that quantity of lead arsenate used alone. Tests indicated that materials added to lead arsenate to increase its adhering or sticking properties enhanced its insecticidal value. Oil sprays were effective when combined with such insecticides as lead arsenate and nicotine sulphate, especially with nicotine. The Massachusetts station observed that a spray applied three weeks after the calyx spray is more effective in combating the plum curculio and codling moth

than was hitherto supposed. The New Jersey stations found that both talc and mica dusted on foliage bearing codling-moth eggs killed the young larvae.

In tests at the Indiana station baits containing geraniol proved very attractive to codling moths, particularly during the dry summer months. Aromatic chemicals used alone were of no value under Indiana conditions. Bait traps were used successfully at the California station as indicators of codling-moth activity and as a means of timing sprays. The use of bait traps as a supplementary control was uneconomical in Indiana where the injury could be held to 10 per cent or less by banding, orchard sanitation, or other means. The New Jersey stations observed that 91 per cent of the emerging moths came from the trunk in the rough bark region and 9 per cent came from the top. In experiments with the codling moth on the English walnut, a relatively large percentage of worms was found by the California station to be killed by lead arsenate applied a week or two after they hatched.

With the oriental fruit moth the New Jersey stations found nicotine sulphate alone to be more effective in killing eggs in the black-spot stage and larvae just emerged than was the nicotine sulphate with resin fish-oil soap added. In laboratory tests in which coarsely ground automobile tire mica was dusted on peach foliage, a high percentage of the newly hatched larvae of the oriental fruit moth was killed before reaching a point of entry. Field tests with talc and mica showed that talc sticks better and is more effective than mica or hydrated lime in reducing larval entry into peach twigs.

In further control experiments with the pear psylla at the New York State station, all lubricating oils tested in cold-mix emulsions and the various commercial oil preparations proved effective in reducing the number of adults and rendering the trees uncongenial to them. A late dormant application of one of the oil emulsions or miscible oils by the Michigan station resulted in comparative freedom from the pear psylla during the first half or two-thirds of the growing season and sometimes for the entire season.

In experiments on the control of the San Jose scale in peach and apple orchards at the New Mexico station,

practically 100 per cent control was obtained from a delayed dormant application of a 4 per cent oil emulsion with casein spreader, no injury to the trees being observed. The Michigan station found that the oil sprays are not to be relied upon in combating aphids attacking tree fruits, but that nicotine sulphate should be applied in the late dormant or prepink stage. The New Jersey stations found that the application of oil emulsion and free nicotine or oil emulsion and crude cresylic acid, 0.5 per cent strength, destroyed approximately 100 per cent of the eggs of the European red mite and apple aphids without appreciable damage to the tree.

The use of a dust consisting of sodium fluosilicate 70 per cent and diatomaceous earth 30 per cent, applied at the rate of 50 pounds per acre, was found by the California station to give satisfactory control of the snowy tree cricket on raspberry in the Santa Clara Valley, where it has caused heavy losses. This dust, applied between the first and second crops, when few or no berries were on the bushes, gave perfect control in 15 days.

The false-blossom disease of cultivated cranberries, which has spread rapidly in New Jersey during the last five years, was found by the New Jersey stations to be carried from plant to plant in a bog by the blunt-nosed leaf hopper (*Euscelis striatulus* (Fallen)). The spread of the disease was controlled by a late reflow of the bog, made as soon as all of the leaf hoppers had hatched, supplemented by kerosene sprayed on floating leaf hoppers. Eggs were destroyed by holding the winter flowage until July 5. Control was also obtained by the use of pyrethrum sprays. An important disease of the black-headed fireworm on cranberries was found by the Massachusetts station to be caused by *Entomophthora sphaerosperma*. This fungus appears to be killed directly or indirectly by late spring or summer flooding or by sanding or spraying.

The Florida station, using calcium cyanide dusted under the fumigation tents, found a heavier concentration of gas necessary to kill white flies than either the purple scale or the Florida red scale. This station observed that the southern green stinkbug is attracted to *Crotalaria* when it begins to bloom, and that it will not leave the plants for citrus fruits as long as green succulent pods remain on the plants. Beta-naphthol treated bands

were found by the California station to prevent reinfestation by mealybugs attempting to ascend the trees after they had been washed off by a stream of water. Trapping and destroying the ovipositing mealybugs and egg masses on bands or pieces of burlap placed in the trees was a promising supplementary practice. In the control of fire ants on the trunks of citrus trees, the Texas station obtained good results from dry sulphur or sulphur wash.

An almost complete control of the willow weevil was obtained by the California station with baits of willow twigs treated with Paris green placed at the base of each tree, which was also banded with a sticky preparation.

Field crop insects.—The Michigan station observed that many European corn borers occur in corn stubble, that low-cut stubble harbors fewer borers than high stubble, and that those below the ground as well as those in short stubble may be disposed of by clean plowing. The Ohio station reported that where ear corn is kept dry the European corn borers contained therein are not an important source of reinfestation in that State, and that this applies likewise to borers overwintering in barn-stored fodder. The California station found that the application of extra-light sodium fluosilicate (70 to 75 per cent) at the time ears reached market maturity was the most effective method of protecting sweet corn from infestation by the corn ear worm. Black pepper and a pyrethrum extract showed promise as repellents. The severe damage to young corn following red clover caused by the grape colaspis, the Illinois station found, could be controlled by early fall or early spring plowing in the clover field; most of the damage occurred in the fields plowed late in the spring. The South Carolina station found that the maize billbug can withstand complete submergence in water for three weeks.

With the boll weevil the Florida station found the most effective and economical method of poisoning to be the application of the arsenical as soon as the cotton first squares and continuing for about four weeks or through June, by which time practically all of the weevils emerging from hibernation in the open have found their way to the cotton fields. Hibernation studies during three successive seasons showed the heaviest emergence to extend from late in May through June, the maxi-

mum emergence occurring about June 18. The Texas station found that increased yields varying from 63 to 206 pounds of seed cotton per acre were obtained by airplane dusting when from three to five applications of calcium arsenate dust were made. It appeared that this method of applying dust should prove profitable for cotton growers where the infestation averages 15 per cent early in the season or 20 per cent later in the season and weather conditions favor increased weevil injury. The Florida station found that the last of 5,000 weevils captured in the fall near Gainesville and placed in a hibernation cage without food in November emerged on July 16 after having spent 257 days in the cage without food.

Comparative tests of the efficiency of arsenicals in combating the alfalfa weevil, carried on by the Nevada station, gave results favoring dusting, and it is thought that this method may replace spraying in western Nevada.

Marked increases were obtained by the Louisiana stations in the percentages of sugarcane-borer eggs parasitized through the release of more than 16,000,000 parasites (*Trichogramma minutum*) in the fields of corn and sugarcane in five localities.

In studies of the relation of leaf hoppers to curly top in beets, the California station found a microorganism in infective beet leaf hoppers that probably has a filtrable stage in its life cycle. It was shown that noninfective beet leaf hoppers after feeding on unfiltered root juice extracted from diseased beets, also on juice filtered through fine Berkeley candles, heated for a period of 10 minutes in water at 70° C., transmitted curly top to healthy beets.

For control of the mint flea beetle the Michigan station found a mixture of finely powdered Paris green, 1 part, with talc or a cheap grade of flour, 20 parts, applied as a dust, to be more effective than other insecticides employed.

Working with the carrot-rust fly, the New York State station found that carrots planted after June 1 ordinarily escape damage, and that if such late-planted carrots are harvested by September 1 to 15 they should be exempt from serious injury. The Massachusetts station obtained promising results from the use of corrosive sublimate and sodium fluosilicate against the first generation of this insect and found that the attack of the

first-generation larvae can be avoided by planting about three weeks before the fly-free date.

The tomato suck fly, which has become a problem in the southwestern part of Texas, was treated by the Texas station, with encouraging results, by the application of dry sulphur or a sulphur-naphthalene mixture.

Effective control of garden cutworms was secured by the Massachusetts station with a sweetened bran mash, sodium fluosilicate and white arsenic proving less effective than Paris green.

Damage by the pepper weevil was prevented, in cooperative control work by the California station and the Department of Agriculture, through the repeated application of calcium arsenate dust at rates of 6 and 8 pounds per acre.

The onion maggot, which frequently destroys 50 per cent or more of the onion crop in some large producing sections, was controlled on a commercial scale by the Illinois station with a 2 per cent boiled lubricating-oil emulsion in Bordeaux mixture. A home-made nicotine dust at 2.4 per cent strength was found by this station to be the most effective of many materials for control of the onion thrips. In further work with this pest at the Massachusetts station, a combined spray of nicotine sulphate and a soft, pourable potash fish-oil soap gave satisfactory control. When repeated at from 7 to 8 day intervals it reaches newly hatched young and migrants from near-by fields. An efficient sprayer adapted to the field spraying of onions was developed.

Garden slugs were successfully combated by the California station with a spray consisting of potassium alum or ammonium alum, 0.75 to 0.5 pound per gallon of water, applied at night. The Illinois station found that the greenhouse leaf tier could be controlled successfully by dusting the underside of the leaves with a mixture of 85 per cent of sulphur and 15 per cent of arsenate of lead.

A very practical control for the destructive cyclamen mite was developed by the Illinois station, using paradichlorobenzene. Placing about one-sixth ounce of this chemical, or a paradichlorobenzene ball the size of an ordinary moth ball, in the cyclamen flats when the plants are first set out almost completely rids plants of mites, even when heavily infested.

The earlier discovery by the Wisconsin station of the transmission of alfalfa yellows by leaf hoppers was confirmed by the Kentucky station, which found that *Empoasca fabae* does great injury to clovers and alfalfa, and that a single adult or nymph may cause the death of young plants. Foreign clovers were found to be injured much more severely than native strains. The Illinois station found the cutting of alfalfa as soon as injury begins to appear, the use of native red-clover seed, and the use of adapted varieties of soybeans to assist in combating the apple leaf hopper.

Control measures.—The Maryland station found that nicotine in greatly reduced dilutions could be used successfully against aphids by adding sulphonated oxidized gas oil instead of the usual spreaders. The sulphonated oxidation products of gas oil consistently gave better results than those prepared from oxidized kerosene with no apparent increase in toxicity to plant foliage.

In a study of the effect of heat on insects, the Missouri station found that a temperature of 125° F. maintained for 24 hours was sufficient to kill all of the insects in the several stages tested. In a comparison made of seeds, all of 20 different kinds withstood 140° for 24 hours without injury. Paradichlorobenzene used at the rate of 1 pound to 100 cubic feet of space for 48 hours was enough to kill all insect life and at the rate of 1 pound to 1 cubic foot did not injure seeds.

Studying the effect of high-frequency radio waves on insect activity, the New Jersey stations found that after exposure to waves of 24 meters and 12,000,000 cycles per second with the ammeter reading about 1.75 amperes the insects were killed, owing apparently to the development of internal heat of lethal degree. All organic chemical compounds with which the station worked and which were more or less characteristic of living tissue showed ability to increase in internal heat when subjected to such high-frequency waves, especially cholesterol, which is characteristic of nervous tissue.

As a repellent for flies the Texas station found that pine-tar oil with a specific gravity of 1.065, plus enough lubricating oil to make the mixture hold well, was the most effective.

Fermenting sugar baits were found by the Pennsylvania station to be espe-

cially attractive to the cherry fruit fly and cutworm moths. While the codling moth and red-banded leaf roller were attracted freely, it seemed doubtful if the baits could be relied upon to control them.

Work with bees.—Studying the digestion of pollen by the adult honeybee, the Wisconsin station found that it was taken into the digestive system in suspension. That the mandibles do not function as chewing organs as previously supposed was demonstrated by the absence of cracked grains. It was found that when pollen in excess is fed with sugar sirup to bees in periods of confinement in winter dysentery does not necessarily develop. The Texas station found that bees become inactive as soon as the temperature reaches 94° F. with a relative humidity below 50 per cent. A study of the poisoning of bees from cotton which had been sprayed or dusted with insecticides indicated that the bees were killed only where the poison was applied to the cotton with a sweet adhesive mixture or where honeydew was present upon the leaves.

WILLIAM A. HOOKER.

ANIMAL PRODUCTION

Research in animal production continued to make progress during the year in increased attention to basic problems of animal nutrition, improved methods and facilities for investigation, more careful planning of projects, and development of efficient cooperation.

Nutrition.—Animal nutrition, one of the most basic and fundamental lines of inquiry in animal production, is receiving the attention of investigators in every section of the country. Rather elaborate equipment is necessary in nutrition studies with large animals, and the Pennsylvania and New Hampshire stations, in particular, have constructed special buildings for housing such apparatus. Other stations, now with inadequate plants, are either curtailing the studies to fit their present equipment or are planning to enlarge the scope of their studies by adding to their present organization. During the year the California, Louisiana, and New York Cornell stations have provided for laboratories for digestion and metabolism experiments.

Several stations are studying the value of ultra-violet radiation in poultry production. The Kentucky station found that the average percentage of eggshell declined as the laying

period was prolonged with all hens, but that those hens exposed to direct sunlight or irradiated with ultra-violet light always laid eggs with heavier shells than hens confined behind ordinary window glass. The same study also demonstrated that different breeds of birds laid eggs differing significantly in percentage of shell.

Exposure of chicks to direct sunlight for an average of 10.9 minutes daily sufficed to promote normal growth and to prevent the development of rickets at the New York Cornell station, although 13.7 minutes' daily irradiation was found necessary for complete protection. At the New York State station birds exposed either to direct or reflected sunlight at 10-day or even 20-day intervals, after winter confinement for about three months, maintained a good rate of egg production, and a large percentage of strong chicks were hatched from the eggs. For normal ash deposition in the leg bones of chicks about three times as much radiation with ultra-violet light filtered through a glass substitute was required at the New Jersey stations as with exposure to the direct rays of the sun. At the Pennsylvania station chicks confined behind a glass substitute had better ash-depositing ability than similar chicks fed cod-liver oil or irradiated with ultra-violet light.

At the Illinois station the blood hemoglobin content of pig's blood was found to decline rather sharply from birth to one week of age. If the pigs were exposed to direct sunlight the blood hemoglobin began to increase after the second week and reached levels approximating those at birth, but when the pigs were not exposed to sunlight the same initial decline occurred, and there was no apparent recovery in the hemoglobin content. At the Indiana station exposure of pigs to direct sunlight, beginning at 1 to 3 days of age and continuing to 35 days of age, had no effect upon the red-cell or hemoglobin content of the blood.

Studies of the effect of minerals upon the health, growth, and reproductive abilities of animals have so advanced that practical application may be made of some of the findings. Dairy cattle fed fluorine (calcium fluosilicate) at the Michigan station went off feed very shortly after mineral feeding began. In one case a heifer fed fluorine remained appar-

ently normal in health and general appearance during her gestation period, but after freshening her appetite was poor, she lost weight rapidly, and at the end of her lactation period was quite emaciated, and the grinding surfaces of the molar teeth were sensitive to cold water. With rats at the Iowa station growth and reproduction failed when calcium fluoride was fed at levels as low as 0.25 per cent, and teeth and bone defects were evident when fed at a level of 0.05 per cent.

Iodine has been found to be a very important mineral for normal health and growth, studies at the Iowa station indicating that 0.05 grain of potassium iodide per head per day was enough to protect ewes against iodine deficiencies. The Illinois station found that the addition of iodine to a good mixed grain ration did not affect the growth of chicks.

Calcium and phosphorus are the minerals in which livestock rations in this country are most likely to be deficient. The Montana station showed that while the calcium content of the crops, soil, and water was adequate in sections of Montana reporting cattle with depraved appetites, all of the crops were low in phosphorus. Analysis showing that the soil had a phosphorus content apparently adequate suggested that even in soils high in calcium or phosphorus the minerals may be in forms not available to crop plants. At the Missouri station, sows on low calcium diets farrowed a high proportion of dead pigs, had poor appetites, lost weight, and had scanty milk flow; and their pigs did not grow well. The Ohio station showed that the proportion of calcium and phosphorus was more significant than the amount of the respective elements in the ration. The most favorable ratio for hogs lay between 1:1 and 2:1, and for poultry between 3:1 and 4:1. Hens on a calcium-deficient ration at the Kentucky station laid eggs that gradually decreased to 0 in hatchability, and a reduction occurred in the percentage of fertile eggs, in the size and number of eggs laid, and in the weight of the eggshells.

Quality and palatability of meat.—Twenty-two State stations and five Federal stations cooperated during the year in research on this problem under the sponsorship of the National Livestock and Meat Board. The American Society of Animal Production is aiding in the development of this study, especially through cooperation and ad-

vice of its committees. The United States Department of Agriculture cooperated with a number of stations in this project by conducting the slaughtering, laboratory, and cooking phases of the study. The requests for such cooperation have been so heavy that the meats laboratory at the Beltsville, Md., farm has had to be enlarged. The cooperative soft-pork studies have been incorporated under the general project "quality of meats."

Methods for measuring have had to be developed as the work progressed. In general, investigators are realizing the limitations of personal judgment, and methods for measuring such characteristics as tenderness, connective-tissue content, muscle structure, color, and the nature and amounts of proteins are being studied. Distinct improvement has been made for measuring certain factors. Chemical and histological studies have brought out facts never obtained by earlier methods.

Only the progress of the work has been reported, since definite results are not yet available. Most of the findings were in regard to the effect of feed upon the color and chemical composition of meat; the relation of age and sex to the kind, quality, and quantity of carcass; the differences in carcasses produced by different breeds; and soft-pork data. Preliminary results were made available on the relationships between the grade and characteristics of cattle as feeders, as slaughter cattle, and in the carcasses. A simple, inexpensive method of expressing in a single figure the market desirability of a beef carcass was outlined by the Texas station and the United States Department of Agriculture.

Beef cattle.—While the production of beef cattle is a phase of animal husbandry important in every section of the country, the problems of any one section vary widely from those in another section, and often solutions of these problems are more or less local in application. Economical production, the most important phase of this industry, is being approached from all angles by investigators.

The California station in a study of the percentage calf crop as a major factor in economical beef production showed that with beef cattle, failure to conceive is more important than infectious abortion. A faulty plane of nutrition, restricted mineral intake, and weather conditions are all associated with failure to conceive.

The control of these factors is not always simple, and especially is this true of mineral deficiencies, for while bone chewing and associated symptoms are outward manifestations of a deficiency it is entirely possible for animals to be on a deficient ration without showing any symptoms.

A comparison of pasture and dry-lot feeding at the Ohio station indicated that steers on pasture gained faster and more economically than those in dry lot, yet showed less finish until the latter part of the feeding period. In studies with range cattle at the New Mexico station it was found that adding cottonseed meal to a wheat-straw ration increased the digestibility of the nutrients of the straw. An increase of approximately 2.58 per cent in the digestibility of the crude fiber of the straw followed the feeding of cottonseed meal.

Sheep.—The growing tendency toward development of more and smaller flocks of sheep on farms in all sections of the country has created a demand for information on feeding and management applicable to this type of production.

Since only a few of the breeding ewes are purebred or even high grades of mutton breeding, considerable interest has been shown in the use of purebred rams for siring market lambs. At the California station Rambouillet ewes were mated to rams of six different breeds. The Suffolk crosses weighed more at birth and gained faster in weight than other crosses, but the largest number of choice and good carcasses were found in the Southdown and Shropshire crosses. In practically every respect the lambs sired by Rambouillet rams were inferior to crossbred lambs. Over a period of four years lambs sired by Hampshire rams at the Montana station weighed more at five months of age than lambs sired by Rambouillet rams. At the Mississippi station lambs sired by Shropshire rams and out of native ewes weighed more at birth than lambs sired by Dorset, Southdown, and Merino rams.

Both single and twin lambs sired by Hampshire rams at the Nevada station gained faster than single and twin lambs sired by a scrub ram. Native mutton lambs made as rapid and economical gains as western lambs in tests at the Ohio station, but were not as uniform at the end of the feeding period, while native fine-wool lambs were inferior to the other types in rate and economy of gains, but yielded heavier fleeces.

The Oregon station found that in order to kill brush, goats must be closely confined, and the brush overgrazed to such an extent that other feed is necessary for the animals. In this section goats ate practically all the green growth of deciduous shrubbery and conifers.

Swine.—Research in swine production has extended beyond the field of feeding and management to include nutrition and other fundamental studies. The Iowa station reported preliminary results of a swine-performance record, an endeavor to set up an exact method for measuring the efficiency of swine breeding stock. The general scheme consists of selecting a certain number of pigs from a litter, starting them on a specified ration at 65 days of age, and feeding them to an average final weight of 225 pounds. Growth measurements and live-weight increases are recorded, and slaughter data obtained on representative pigs of the group. This system will make it possible to assign to a particular sow at least an approximate value for her offspring, and through the pigs by one sire an approximate value of his transmitting ability. A new feeding standard outlined by the station for fattening young swine, based on pounds daily of crude protein and fiberless-carbohydrate equivalent per unit of live weight, emphasizes the full feeding of low-fibered, high net-energy-carrying feeds, adequate minerals and vitamins, a supply of nutritively adequate proteins, and palatable feeds.

The Illinois station observed that time is not a controlling factor in either rate or economy of gain in swine. From the butcher's standpoint the intermediate type of swine produced the most desirable carcass, but the rangy type if self-fed was usually satisfactory. At heavier weights the intermediate-type pigs were more economical of food energy in maintenance, but no type differences were detected in feed utilization.

Poultry.—Concurrent with the increase in the numbers of poultry and a growing appreciation of the economical factors involved, there has been a decided improvement in the quality of research with poultry. New methods of feeding and management have been required by the recent practice of raising large numbers of birds on small areas. Indicative of the importance of the poultry industry is the new poultry plant built and equipped at a cost of \$80,000 by the California station.

Washing the inside of an incubator with warm water and washing powder previous to use was found by the Michigan station to be the greatest factor in reducing bacterial counts. The use of disinfectants still further reduced the count, rendering the incubator practically sterile. However, the air passing through the ventilators tended to increase the bacterial infection as incubation progressed, the greatest counts on agar plates occurring at hatching time.

The best practice for improving vigor in production-bred flocks, according to Massachusetts station studies, consisted of breeding exclusively from families showing the lowest mortality of pullets in the laying house. In this work it was found that mortality in chicks up to 8 weeks of age was not a reliable index of vigor because it bore little relation to mortality rates in the same families after surviving daughters were placed in the laying house. Such factors as high hatchability, the occurrence of broodiness before July 1, and fixing early maturity, high intensity, nonpause, and high persistency did not decrease vigor. Late hatching decreased the vigor of chicks slightly, and breeding out of broodiness, at least in Rhode Island Reds, had a detrimental effect upon vigor. Age at first egg, genetic early maturity, weight at first egg, winter pause, and intensity of laying could not be used as measures of vigor.

A fertility study with poultry at the Iowa station showed that in 19 of 35 successful single matings the first fertile egg was laid between 36 and 48 hours after mating, in 13 matings between 60 and 72 hours, and in 3 matings after 84 hours. The average onset of fertility was about 57 hours after mating. From a single mating fertility endured from 4 to 21 days, with an average of 11 days, and a single mating produced an average of 5.5 fertile eggs. Results in studies of double matings indicate some selective fertilization. Hens had longer periods of fertility than pullets, and matings with cockerels produced more fertile eggs than matings with cocks.

A decrease in the number and in total weight of eggs laid by White Leghorn hens the second year as compared with those laid the first year was recorded by the West Virginia station. There was a tendency during the pullet year for the birds to become heavier with increasing age, but the

average weight per bird during the yearling year exceeded the average during the pullet year.

No harmful effects followed the early feeding of baby chicks at the Indiana and Wisconsin stations, and the rate of growth of chicks so fed was approximately the same as in lots held off feed for 48 hours.

Dairy cattle.—Although the number of cattle used for milk production in this country does not materially change from year to year, there is a concerted effort on the part of all agencies connected with the industry to improve the quality of the cattle and the sanitary surroundings under which the milk is produced.

The problem of economically replacing the cows that have outlived their usefulness becomes more and more acute as the demand for whole milk, the value of land, and the capital invested in dairy farms increase. At the South Dakota station self-fed calves outweighed hand-fed calves up to 4 months of age, but did not grow any faster in height at withers, and over a 10-month period gained less than the hand-fed calves. In some cases self-feeding caused physiological disturbances and abnormal development. Hand feeding produced calves more economically than self-feeding. Powdered skim milk fed to calves at the Ohio station produced growth and weight gains in a satisfactory manner. Either spray or roller process skim milk was as satisfactory as and a more economical feed than whole milk for dairy calves. The Wisconsin station found that a liberal allowance of skim milk furnished calves with an ample supply of protein, and with the addition of legume hay made possible the extensive use of farm-grown cereal grains in the growing ration.

Cooperating with a commercial laboratory, the New Jersey stations observed that humidity, and not temperature, affects milk production. The effect is not direct, but the animals go off feed, and the high-producing animals were more susceptible to humidity variations than low-producing animals. The normal range of humidity for dairy cows appears to lie between 50 and 75 per cent.

Dairy cows at the Illinois station consumed only insignificant amounts of ground limestone and bone meal when allowed free choice of the minerals. The study further showed that 1 per cent of salt in the ration was insufficient to satisfy the craving of

dairy cattle, for when allowed access to salt in self-feeders they consumed rather large quantities.

HENRY W. MARSTON.

DAIRYING

The use of dairy products is increasing in the United States, and with greater consumption has come a growing demand for high-quality products. Better equipment and better methods of procedure are constantly being introduced into the industry, and new problems of distributing and marketing, especially in regard to the quality of the product, arise frequently. The extent of this phase of the dairy industry and the great demand for information have caused many of the stations to increase their equipment. For example, new dairy industry buildings, well equipped with modern machinery and facilities, have been opened by the Illinois, Iowa, and Louisiana stations during the year.

From studies of methods and agencies for cleansing dairy equipment, the Oklahoma station reported that ordinary washing methods, followed by a rinse of scalding water, were not adequate for treating dairy equipment. Sodium hypochlorite and its compounds, when furnishing a minimum of 45 parts of active chlorine per million of solution, were effective when used to clean utensils. The Illinois station demonstrated that solutions containing active chlorine should be applied just before the utensils are used, and should be in contact with all surfaces for at least 10 seconds in order to kill the bacteria, and that such solutions were only effective on surfaces free from dirt and grease.

Thoroughly worked butter, according to experiments of the New York Cornell station, has a more uniform composition, shrinks less, keeps as well, contains somewhat more air, and is as satisfactory as medium-worked butter. The Wisconsin station found that the use of citric acid or sodium citrate with milk for butter starters produced very satisfactory results, and in most cases competent judges preferred the treated to the untreated cultures. From four to seven times more soda solution than lime solution was required at the Arkansas station to neutralize the same percentage of acid in cream. There was a difference of not over 0.1 point in the scores of butters made with lime and with soda neutralizers.

Studying the value of egg yolks in ice cream, the Kansas station found that egg yolk improved the whipping qualities of relatively heavy slow-freezing mixes to a greater extent than those of mixes with a comparatively low-solids content. Less than 0.5 per cent of yolk had little or no influence on the body, texture, appearance, or flavor of mixes containing the correct proportions of milk solids and sugar. Egg yolks imparted a flavor at times objectionable, especially in mixes of low-solids content. At the New Jersey stations yolks improved the texture but not the stability of a mix, and the use of more than 1 per cent affected the flavor unfavorably. Dried whole egg was nearly as effective as dried yolks for improving ice-cream mixes, but the use of egg albumin was detrimental. The Michigan station found that vanilla flavors obtained by the use of single-strength extracts from all Mexican beans gave best results in ice-cream mixes. The flavoring extract was volatilized only slightly by aerating, or by slight melting and refreezing of the ice cream.

In a process for pasteurizing cheese curd in the vat, perfected at the Wisconsin station, hot water is applied to the curd after milling at an acidity of 0.6 per cent; the curd is kept at 145° F. for 30 minutes and cooled to 90° by adding cold water; it is then drained, salted, and pressed. With good-quality milk no improvement in the quality of cheese was noted, but with second-grade milk a marked improvement occurred in the flavor and texture of the cheese. The average loss of yield with this treatment was 0.15 pound on a 10-pound cheese.

HENRY W. MARSTON.

ANIMAL DISEASES

Investigations relating to animal diseases were carried on at a number of stations during the year, those with infectious abortion, fowl pox, and bacillary white diarrhea or pullorum disease of the fowl being especially significant. The rapid advance in the general knowledge of the relation of the former to undulant fever of man stimulated interest in the work with the causative organism.

Infectious abortion.—Work on infectious abortion was continued by no less than 12 stations. The California station reported progress in perfecting methods of detecting the disease and

in determining conditions under which the germs are discharged in the milk of diseased animals. Type studies made by the Michigan station led to a more definite differentiation of three strains or species of the causative organism. In a study of the spread of the disease in swine the Missouri station found that a large percentage of the progeny of positive-reacting dams and granddams was susceptible to the organism through cohabitation.

There was considerable activity in the field of vaccination both with the virulent and nonvirulent virus. The resistance to *Brucella abortus* conferred by vaccination with live cultures was found by the California station to persist in certain cases for at least three regular gestation periods. Living cultures of the organism were administered by the Texas station as a vaccine over a period of three years, some protection being obtained, and the breeding efficiency did not decrease. During the 3-year period that the vaccination was practiced in the herd the percentage of abortion was 5.5 as compared with an average of 23.76 during the 10 years immediately preceding. Seven years' study of the avirulent culture by the Michigan station indicated that safe and effective vaccination against the disease is a hopeful possibility that may yet be made of practical value. Living-organism vaccines failed to give satisfactory results at the Delaware station, where two methods of segregating the reacting and nonreacting animals were employed with success—in the one they were separated at calving time only, while in the other they were separated at all times. During control work lasting 10 years both systems were used successfully in eradicating the disease. Control by means of isolation during 5 years at the Minnesota station confirmed earlier conclusions that the organism does not spread rapidly among two groups of animals entirely separated in barns not more than 75 feet apart and tended by the same men. In eradication work in the herd at the western Washington station 49 negative cows and heifers were added to those in the herd at the time of the first test, every animal with one exception remaining negative.

That the abortion organism may attack the fowl appears evident, the Michigan station finding natural infection in four flocks. In experimental work most of the 48 fowls artificially exposed to the organism became in-

fectured. In three of the four flocks in which there was natural infection there was a history of decreased egg production. In many experimental birds infected death resulted, recoveries took place in a few, the others being killed at intervals in order to study the nature of the disease. The course of the disease ranged from 18 to 96 days, the lesions varying considerably, depending upon the rapidity of the course.

That the abortion organism is pathogenic for the monkey was shown by the Michigan station, a disease resembling undulant fever resulting, although not readily produced. The monkeys were readily susceptible to an infection by a small dose of the porcine form regardless of its source, the data indicating that it is more virulent for the monkey than is the goat form.

Other diseases of cattle.—In continuing studies of anaplasmosis of cattle, a disease which has come to attention in the United States in the last few years as the cause of a large loss of cattle, the California station found that animals that have apparently recovered from the disease may carry the causative parasite in their blood in sufficient numbers for from 5 to 26 months to infect a susceptible animal. It was observed that calves born of cows recovered from the disease do not carry the infection in their blood and are susceptible to it. Pregnant cows may pass through a severe attack of anaplasmosis and not transmit the disease or confer an immunity to their offspring. A new method of staining blood smears revealed that the marginal bodies usually occurring in the red blood cells in cases of anaplasmosis may take on ring forms somewhat similar to those observed in malaria plasmodia.

As a result of investigation of bacillary hemoglobinuria, or red water, due to *Clostridium hemolyticum bovis*, a vaccine was prepared by the Nevada station which protected cattle and stopped the losses of sheep entirely after the lapse of one week. Complete eradication for eight months with no bad effects was obtained by the administration of 5-cubic-centimeter doses of living nontoxic cultures of the organism plus 25 per cent glycerin. Comparing fore and middle milk and strippings in cases of udder infection to establish a norm, the Idaho station found the most repre-

sentative sample of udder flora to be obtained from the middle milk.

In investigations on infectious mastitis the Connecticut Storrs station found that autogenous bacterins even when given in small doses exerted a marked curative action in severe cases, and that a prophylactic vaccination at intervals of approximately three months was apparently efficacious in at least two of the herds studied.

The Texas station found that the difficulty known as "creeps" in cattle did not develop in animals receiving bone meal but that it did develop in many of the control animals. The advantage of feeding the bone meal and salt mixtures was found to continue until the animal is at least 3 years old.

When reactors to the test for Johne's disease and suspects were removed by the Mississippi station to a separate part of the farm and the premises thoroughly disinfected, none of four calves taken from an infected herd reacted.

A fatal disease of horses prevalent in certain parts of northwestern Nebraska was determined by the Nebraska station to be essentially an enzootic necrobiosis and cirrhosis of the liver due to a toxic agent. It was found that the disease can be produced by feeding with plants of *Senecio jacobellii*.

In studies on anthrax the Arkansas station found that the use of a blood-serum medium for the cultivation of the causative organism offers a method for the preparation of a potent anthrax antigen and suggests strongly that the method may prove a valuable aid for the protection of farm animals against the disease.

Experiments on botulism at the Illinois station indicated that formalin and heat may detoxify the botulinum toxins without altering a measurable amount of antigenic substance.

All of the above-ground parts of *Drymaria pachyphylla* were shown by the New Mexico station to be poisonous at all stages of maturity. The plant proved to be very deadly and the cause of large losses of cattle in the State.

Diseases and parasites of sheep and swine.—That pathogenic spore-bearing anaerobes can be isolated from the spleens of a considerable proportion of sheep dead of a variety of diseases was shown by the Colorado station. It is concluded that in the case of *Clostridium oedematis* the longer the animal has been dead the greater is the

possibility of its presence in the spleen.

In studies of the sheep liver fluke the larval form was detected by the California station in cooperation with the Department of Agriculture in the snail *Galba bulimoides*, which occurs in every range in northern California where the liver-fluke infestation was epidemic.

The common stomach worms of sheep and goats were found by the Texas station to be effectively controlled by the administration of tetrachlorethylene in gelatin capsules of 5 cubic centimeters for mature animals and 2.5 cubic centimeters for kids.

In investigations of an apparently new type of pneumonia in swine the California station isolated a bacillus which was believed to be the cause of the disease, and an aggrassin was developed which seemed to give some protection.

The nonembryonated ascarid eggs from swine were found by the Illinois station to pass through the digestive tract of domestic fowls and remain viable, thus suggesting the possibility of domestic and wild birds being agents in their spread. Embryonated eggs, however, were destroyed by passing through the digestive tract of chickens.

Bacillary white diarrhea or pullorum disease.—Investigations on pullorum disease (bacillary white diarrhea) of poultry were continued by a number of States. In a further study by the Rhode Island station of the gas-forming characteristic of the causative organism in dextrose broth, a temperature of 30° C. was found to be the most favorable. Eight of a hundred strains tested, however, failed to form gas at any of the incubation temperatures. There appeared to be no relation between gas formation and the pathogenicity of strains of the organism.

Progress was made by a number of stations in work with the agglutination test for the disease. The Arkansas station found that fowls reacting at a serum dilution of 1 to 10 are carriers of infection and should be removed from the flock, and that when a dilution of 1 to 25 is used as a basis for removal, many that are infected escape detection and remain in the flock to spread the disease.

Sodium hydroxide was found by the Arkansas and Idaho stations to be the most efficient in preventing cloudy reaction. The rapid plate method of

testing for the disease was found by the Western Washington station to be in complete agreement with the tube test in a high percentage of the tests. It was found by the Kentucky station to be less satisfactory than the tube test at dilutions of 1 to 80 or higher. Several stations reported finding the agglutination test to be more accurate than the pullorin or intradermal test. Ninety-six per cent of the tests made by eight laboratories of sera from 25 reactors were in agreement.

Recent work at the stations indicates that pullorum infection of the lung is the cause of much of the so-called brooder pneumonia. This is the conclusion of the Kansas station, which found that when the lung is thus infected, chicks may die without any symptoms of diarrhea and that the affection may be as fatal as when it occurs in the digestive tract. In incubator fumigation 0.35 cubic centimeter of formalin mixed with 0.175 gram of potassium permanganate was found by the Kansas station to be the correct dose per cubic foot of incubator capacity, this dose being effective in destroying the organism and not affecting the hatchability of the eggs. Lung infection with this organism was found by the Michigan station to be quite common in young chicks, the infected lungs usually showing small grayish nodules. The Illinois station concluded that brooder pneumonia is in most cases a lung type of pullorum infection. The station found that in one group of fowls reacting to the agglutination test for pullorum disease which was kept in the same pen with nonreacting fowls for several months the disease gradually spread when nonreacting males were added to the pen.

The darkening of a brooder for 72 hours after hatching occurs was found by the Ohio station to be of value in controlling the spread of pullorum disease in chicks. The causative organism in nonfertile incubator eggs was found by the Pennsylvania station to be destroyed by boiling for five minutes. That pullorum infection may readily spread among adult fowls by association of noninfected and infected hens without the presence of males was the conclusion of the California and Kentucky stations.

Poults from 2 to 3 weeks of age were found by the Michigan station to be infected with *Salmonella pullorum* from contact with baby chicks which later showed evidence of the disease.

Fowl pox.—Fowl pox, an important limiting factor in poultry production, was given much attention by the stations, the work being aimed particularly at prevention through vaccination. The Ohio station concluded that any of the several methods of cutaneous vaccination are effective in producing immunity to pox. The Western Washington station found that immunity to cutaneous vaccination may last as long as two years. It produced complete protection against subsequent natural infection of fowl pox. Vaccination resulted in the production of an active immunity in the pullets and nonappearance of the disease in several commercial flocks in which it had been endemic for several years in Idaho. In the cutaneous vaccination at the New Hampshire station it was found that the smaller the number of follicles infected the less the evidence of vaccination sickness, any number of follicles from 3 to 12 appearing to confer lasting immunity. The California station found that the vaccination of healthy cockerels and nonlaying pullets or hens was a relatively safe procedure. The Indiana station observed that chickens vaccinated in the skin of the leg with unattenuated fowl-pox virus did not develop symptoms of pox or roup following pen exposure to the disease or inoculation of the comb with pox virus. It was found by the Illinois station that avian diphtheria can be reduced and possibly eliminated in many flocks if cutaneous fowl-pox vaccine is properly used during August, September, and October before the fowls go into winter quarters.

Other poultry diseases.—The California station obtained good results from the use of the autogenous bacterin for fowl typhoid in a flock of hens and roup in a flock of pigeons. *Aspergillus fumigatus* was found by the Michigan station to cause an affection of the kidney and other visceral organs of the chick characterized by necrosis.

So-called infectious bronchitis has become a serious infection of poultry in the United States. The infectious nature of this disease was demonstrated by the Western Washington station both from natural outbreaks and experimental inoculations. The Illinois station showed that the disease may be communicated from infected to healthy fowls by contact or by pen exposure, that the disease is highly contagious and the virus is present in the mouths and respiratory tracts of infected birds, and that an acute septi-

cemic form of bronchitis in fowls may cause death in a few hours.

That the incidence of fowl paralysis in flocks previously suffering losses from coccidiosis may run as high as 50 per cent and that the association of tapeworms and other intestinal parasites with paralysis is quite marked was the conclusion drawn by the Kansas station. Investigations by the Florida station indicated an association of the disease with the presence of coccidia and of intestinal worms. The Michigan station reported that the small coccidia were found in specimens from typical cases of so-called range paralysis received from Ontario, New Jersey, Ohio, and Illinois in addition to many from Michigan. Pigeons exhibiting symptoms similar to those observed in coccidiosis of chickens, including lameness and paralysis, were found to be infected with numerous coccidia morphologically indistinguishable from those found in chickens, the duodenum being the seat of infection.

The Virginia station found that kamala was effective for tapeworms and nicotine sulphate for roundworms, but that when combined they removed neither tapeworms nor roundworms. The administration of carbon tetrachloride was found by the Kansas station to remove nematode worms (*Ascaridia lineata*) with scarcely any ill effect upon the fowls.

In work on the effect of weed-control chemicals on sheep the Idaho station found that a total of 3 ounces of sodium chlorate or calcium chlorate given in two equal doses four hours apart was sufficient to kill yearling wethers weighing approximately 100 pounds each.

WILLIAM A. HOOKER.

FOODS AND HUMAN NUTRITION

No hard and fast line can be drawn between research in animal and in human nutrition or even between that dealing with foods and feeding stuffs, for fundamental truths concerning nutrition are generally applicable alike to animals and to man, and general principles underlying the occurrence of certain food constituents hold for many foods used for animal as well as human consumption. Many recent developments in animal nutrition have an important bearing upon human nutrition and conversely some of the results to be reported in this section may be of interest to those concerned with animal nutrition.

The more important contributions of the year in this field included further information on the effect of various factors upon the content and stability of the vitamins in foods used for human consumption; the improvement of technic for determining the distribution of the vitamins generally termed B and G and further knowledge of the requirements for these vitamins, particularly in infant feeding; new data by refined technic on the distribution of copper and iron in natural foods and confirmation of earlier work on the importance of these elements in the prevention and cure of nutritional anemia; and practical information on the dietary habits and food expenditures of rural people in various sections of the country. The brief review which follows is intended to serve as an indication of the general trend of research along these lines rather than as a summary of all of the contributions of the year under the topics listed.

Vitamin content of foods.—The distribution of vitamins in cereal grains, particularly corn or maize, has received considerable attention. Determinations at the Texas station on corn secured from various parts of the State indicated that yellow corn contains three times as much vitamin A as strawberry corn and about one hundred times as much as white corn. At the New Jersey stations a yellow dent corn was found to be about 50 per cent more potent as a source of vitamin A than a white-capped yellow dent corn. The heritable nature of such differences was shown at the Indiana station by the distribution of vitamin A in F_2 segregating kernels of crosses of yellow dent and white dent corn. Vitamin A appeared always to be associated with the yellow endosperm and lacking in the corn grains of white endosperm even when both were borne on the same ears. The genetic factors responsible for yellow pigmentation and vitamin A occurrence could not be separated; there was no evidence of vitamin A in grains possessing pure white endosperm, and in hybrid red maize vitamin A was found only in kernels possessing yellow endosperm. These findings are of value to the corn breeder who wishes to produce strains of high nutritive value, and to the farmer concerned with livestock feeding. From the standpoint of food selection they are of value in confirming the general rule that vitamin

A follows yellow pigmentation. Of more practical interest for the housewife is the Michigan station's finding that commercially canned Golden Bantam corn was very high in vitamin A, while the white Country Gentleman variety was almost free from it.

A recently completed part of a prolonged investigation at the Illinois station of the distribution of vitamins in the structural parts and milling products of cereal grains showed the content and distribution of vitamin A in the nine products obtained in the wet-milling process of making starch from whole yellow corn. As noted in the preliminary report of this investigation, the greater part of the vitamin A was recovered in the gluten which, together with the steep water, reel slop, and grits, constitutes the commercial gluten feed. Contrary to the general idea of a concentration of vitamins in the germs, corn germs contained inappreciable amounts of vitamin A when fed as such. The presence of a slight amount in the germ was shown by a fairly high concentration in the crude oil extracted from it, but the refined oil was free from it.

Knowledge of the importance of a liberal supply of vitamin A and of the much higher content of this vitamin in yellow than in white corn has already led to extensive replacement of white corn by yellow corn in animal feeding, but in many sections of the country white varieties of sweet corn still are preferred over yellow and white corn meal over yellow for human consumption. When the food supply contains an abundance of vitamin A from other sources the choice between yellow and white corn is not important, but where the food supply is limited and corn meal is used quite extensively yellow corn is preferable. The Illinois station found that the concentration of Vitamin A in the oat kernel is negligible. Oat oil was found to contain some vitamin A, but in quantities too small to make oats of any value as a source.

The earlier studies at the Illinois station on vitamin distribution in cereal grains were concerned with vitamin B. The differentiation of this into at least two factors necessitated a reexamination of the various cereal grains as sources of vitamin B (F) and G. As this work was started before the technic for determining these factors separately had been developed satisfactorily, this problem had first to be met. In vitamin G de-

terminations tikitiki, an alcoholic extract of rice polishings, was being used as a source of vitamin B, but was considered not to be as free from G as has been taken for granted by some investigators. A study is now under way to determine the exact value of the material as a source of both vitamins B and G in order that proper allowance may be made for its vitamin G content when used as the source of vitamin B in vitamin G experiments.

The possible presence of traces of vitamin G in cornstarch led to the substitution of dextrose for starch in the basal diet. Another precaution considered advisable in vitamin G experiments is to autoclave the material to be tested in order to destroy most of the vitamin B which may be present. Preliminary studies on the distribution of vitamins B and G showed that the whole-grain cereals rice, wheat, corn, and oats are better sources of B than of G, but that they contain appreciable amounts of vitamin G. Autoclaved oats fed at a 50 per cent level as the sole source of vitamin G, with vitamin B supplied by tikitiki, furnished sufficient vitamin G for growth approaching normal. Two commercial oat products used as cereal foods were found to retain almost all of their original vitamin B potency, thus showing no appreciable alteration in the properties of vitamins B and G in the manufacturing process.

Whole corn, hominy feed, and corn germs fed as the sole source of vitamins B and G proved insufficient for the needs of lactation in rats, but normal young were raised when autoclaved yeast was added to increase the vitamin G content of the diet. A further study is being made of the relative needs of the lactating mother for vitamins B and G.

As a direct outcome of the demonstration at the Wisconsin station that many food materials can be rendered antirachitic by suitable irradiation there became available during the past year a number of cereal breakfast foods treated commercially with ultraviolet rays. Monthly tests at the Wisconsin station of the antirachitic potency of two of these commercially irradiated products showed that they conformed to the standards set, and that ordinary cooking does not decrease the antirachitic activity. With the short time of exposure necessary to secure the standard degree of activation no destruction of vitamin A or

the vitamin B complex is considered to take place.

The feasibility of irradiating ice cream was tested at the New Jersey stations, where it was found that when an ice-cream mix of 8 per cent fat content was irradiated with a Cooper-Hewitt lamp in a thin film at a distance of 12 inches for 10 minutes, the desired healing of rickets in rats could be accomplished by feeding the ice cream at a 4 per cent level. The material thus irradiated had an objectionable fishy odor. By increasing the butterfat content of the mix to 18 per cent fat the time of irradiation could be shortened to such an extent that the flavor of the samples thus irradiated was not objectionable.

The Wisconsin station stated that freshly made sauerkraut and sauerkraut juice may be expected to be about half as rich in vitamin C as the cabbage used in its preparation. Commercially canned sauerkraut varied considerably in content of vitamin C, although in general the better brands were about as good sources of this vitamin as the freshly prepared sauerkraut.

Of interest in connection with the question of possible deleterious effects of sulphur dioxide in dried fruits and legislation in some States against the practice was the observation of the California station that while vitamin C was almost completely destroyed during the dehydration or sun-drying of such fruits as peaches and apricots without sulphuring, the sulphured dried fruits showed practically no loss in vitamin C content.

Vitamins B and G and their influence on reproduction and lactation.—Although absolute uniformity has not yet been reached concerning the nomenclature of the two vitamins now known to constitute vitamin B, the recommendation of a committee of the American Society of Biological Chemists that they be called B (antineuritic) and G (antipellagic) was generally followed. Studies on their differentiation were proceeding at the Alabama and Ohio stations. Certain improvements in technic for determining the two vitamins separately in food materials have been made at the Illinois station. The California station emphasized the importance of a uniform basal diet for the determination of vitamin B and recommended as most sensitive for this purpose a diet consisting of 20 parts of extracted casein, 70 of su-

crose, 4 of salts, and 10 of autoclaved yeast.

The Arkansas station has concentrated attention on the specific effects of a deficiency of the vitamin B complex on the blood of nursing young and to differentiate between vitamins B and G in the requirements of the vitamin B complex for lactation. The blood of the nursing young of rats on very limited amounts of the vitamin B complex was found to have a progressively decreasing content of sugar; a more complete examination pointed to the development of anhydremia accompanied by marked fluctuations in the concentration of hemoglobin and erythrocytes. Like symptoms were obtained when the deficiency was limited to vitamin B by the administration of autoclaved yeast as the source of G. Deficiency in vitamin A or in vitamin E apparently had no specific effect upon blood composition. That vitamin G is also concerned in the requirements for lactation was demonstrated with lactating rats by the use of rice polishings (rich in G but low in B) as supplements to a diet deficient in both B and G. The addition of rice polishings alone to the mother's diet caused rapid growth of the young for a short time and then was followed by maintenance. The subsequent addition of autoclaved yeast brought about renewal of growth.

Evidence that vitamin G may be at least as important as B for lactation was also obtained by the Illinois and Iowa stations. The Illinois station found that lactating rats receiving a limited amount of vitamin B and a more liberal supply of vitamin G raised their litters more successfully than rats receiving a limited amount of G and a more liberal supply of B. It was found impossible, however, to secure successful reproduction and lactation when autoclaved yeast was the sole source of the vitamin B complex.

At the Iowa station rats were carried through three generations on a diet containing 50 per cent lean meat autoclaved for one and one-half hours at 15 pounds pressure and supplemented with all the known accessory factors. During lactation various factors which supposedly promote milk flow were added, and the effects of these additions were studied by means of histological examination of mammary gland tissues and hemoglobin determinations of the blood of the young at 28 days of age. The materials

tested have included wheat-germ oil, tikitiki extract, autoclaved yeast, increased yeast in the basal ration, and lemon juice to furnish additional amounts of vitamins E, B, G, B and G, and C, respectively. Of the various additions autoclaved yeast has given the best results, thus demonstrating the importance of vitamin G for lactation.

Medical literature of the past year reported the application to human nutrition of these laboratory findings concerning the increased requirements for vitamins B and G in lactation. Diets exceptionally rich in these vitamins are said to increase both the quality and quantity of breast milk.

Nutritional anemia.—The discovery at the Wisconsin station of the supplementing action of copper for iron in the regeneration of hemoglobin in rabbits and rats rendered anemic by an exclusive milk diet was confirmed by further investigation at the same station and by similar studies at the Ohio and Kansas stations. At the latter station, however, it was thought that manganese also possesses this supplementing action for iron. In the continuation of the Wisconsin studies iron wire such as is used in the preparation of pure iron salts was found to contain sufficient copper to cure anemia in rats when the salts prepared from it were fed at high levels, but when these salts were freed from copper by treatment with hydrogen sulphide they were no longer capable of curing anemia. This suggested that the success reported in the treatment of anemias with heavy doses of so-called pure salts is attributable to copper contamination of the salts. This might also be true in the cure of human anemias with inorganic iron.

Further proof that copper is the element responsible for the supplementing effect for iron in the cure of milk anemia in rats was obtained in the cure of such anemias by pure iron salts supplemented, respectively, by several liver fractions, hydrogen sulphide fractions of the acid extracts of the ash of two of these preparations, and copper as a solution of copper sulphate, all furnishing the same amount of copper. Meantime the Kansas station had reported success in hemoglobin regeneration in rabbits and rats with supposedly pure manganese salts as well as with copper salts as a supplement to iron. The response to manganese was not quite as rapid as with copper, but the re-

sponse to both copper and manganese was more rapid than to either alone. This was thought to indicate the existence of a group of substances rather than a single substance with supplementing effect for iron. This opinion was also shared by other investigators, who reported a response with various other salts.

Prior to the first announcement from the Wisconsin station of the supplementing effect of copper for iron, an investigation had been begun at the Ohio station to determine the nutritive deficiency in milk which is responsible for the production of anemia. Various iron compounds had been found ineffective as a supplement to milk for the prevention of anemia in rats. In accord with the suggestion made by the Wisconsin workers, copper sulphate in 0.16 milligram daily amounts was administered to the rats and was found to be effective when given either as a supplement to iron or alone. The success of the copper alone was thought to indicate that the small amount of iron in milk was rendered more available by the copper and to point to as serious a deficiency of copper as of iron in milk.

The various constituents of ordinary synthetic rations were fed one by one as supplements to the milk, and the materials found effective were analyzed for iron and copper. Of the materials used, agar, casein, starch, and yeast were effective and rice polishings, cod-liver oil, irradiated milk, and wheat-germ oil ineffective. The negative results definitely excluded vitamins B, A, D, and E as having any supplementary effect for milk in hemoglobin production. A rather definite relationship was established between effectiveness in the regeneration of hemoglobin and the proportion of copper and iron in the supplementing materials. The hemoglobin levels were the highest when at least 0.45 milligram of iron and 0.04 milligram of copper were furnished per rat per day, these amounts corresponding very closely with figures reported by the Wisconsin station as most effective.

In order to answer the claim of the Kansas investigators and others that copper, while admittedly effective, is not specific as a supplement to iron in the production of hemoglobin, the investigation at the Wisconsin station was extended to other elements. Pure salts of 12 different elements were tested alone and in combination for

their ability to supplement a diet of whole milk and iron in the production of hemoglobin in rats. Special attention was paid to manganese, including the testing of a sample of the manganese carbonate found effective at the Kansas station. With the exception of arsenic, which produced a slight but temporary effect, negative results were consistently obtained with all of the salts tested.

There is always a question of the validity of applying to human nutrition results obtained in animal-feeding tests, but the more universal the results with different species of animals the more likely they are to be applicable to the human species. The first of these nutritional anemia studies were conducted on rabbits, the later ones on rats, and still more recently the Wisconsin studies were extended to chicks, with similar results. Considerable difficulty was at first encountered because normal growth could not be secured in chicks on an exclusively milk diet, and various additions to the milk contained sufficient iron and copper to render the results valueless. The basal diet finally selected consisted of granulated starch supplemented with alcohol and ether-extracted yeast. On this diet anemia was quickly produced and cured by the addition of purified ferric chloride with minute amounts of copper but not by the iron salt alone.

As the evidence is indisputable that copper supplements iron in hemoglobin production (whatever may be the final conclusion concerning manganese), copper is now added to the indispensable food elements, and a knowledge of its relative distribution in natural foods is of interest. A survey at the Wisconsin station of existing methods for the quantitative determination of copper in biological materials led to the adoption, with certain modifications, of an Italian colorimetric procedure by means of which it is possible to analyze samples containing as small an amount as 0.02 milligram of copper. By the use of this method the copper content was determined of over 150 common food materials which had previously been analyzed for iron and manganese. The figures ranged from 0.1 milligram per kilogram of the fresh material in celery to 44.1 milligrams in fresh calves' liver. Other individual foods relatively high in copper content were oysters, chocolate, cocoa, and molasses. Strangely enough, green vegetables, which rank

high as sources of iron, were relatively low in copper. Arranged in descending order of copper content, the different classes of foods were as follows: Nuts, dried legumes, cereals, dried fruits, poultry, fish, animal tissues, green legumes, roots and tubers, leafy vegetables, fresh fruits, and nonleafy vegetables. Samples of milk from different sections of the country showed only slight variations in copper content, the range being from 0.123 to 0.184 milligram per liter. Attempts to increase the copper content of milk by supplementing the cows' ration with copper were unsuccessful. The Kansas station found, however, that dry whole milk which had been manufactured in copper vacuum pans contained sufficient copper to prevent nutritional anemia in rats when fed with a supplement of iron alone.

The principal conclusion that can be drawn from these studies as a whole is that simple nutritional anemia should no longer be considered from the standpoint of a deficiency of iron alone in the diet, but that attention should be paid to copper as well.

Food consumption and expenditure.—The growth of the cafeteria system in institutions and elsewhere and the expansion of drug-store soda fountains into lunch rooms has made the question of food value received for money spent in such eating places of importance to those who are trying to live economically. The New Hampshire station determined the energy value and protein content of a large number of individual foods and food combinations regularly eaten in college cafeterias and restaurants and at soda fountains, and calculated the results in terms of servings and amounts purchasable for 10 cents. The data reported emphasize the wide variations in food value of different combinations of equal cost and the high calorie value of many of the between-meal and soda-fountain foods. Sandwiches, while varying widely according to their filling, averaged about 200 calories and from 5 to 10 grams of protein for 10 cents. Five-cent package sandwiches, consisting of crackers with various fillings, averaged about 200 calories each, and 5-cent package candies about 225 calories each. The meals served at the home economics practice house for a week averaged 2,450 calories and 61 grams of protein per person per day. Thirty-four dinners selected by the students at the

college cafeteria furnished from 517 to 1,610 calories each, the calories purchasable for 10 cents varying from 165 to 410 and the protein from 6 to 11 grams each. It was thought that more attention should be paid in college cafeterias to giving the students an approximate idea of the value of the food they purchase.

A recent investigation at the Ohio station of the food consumption and expenditures of rural families in the State showed that 16.62 per cent of the total expenditure for food was for milk and dairy products, 25 per cent for fruits and vegetables, and 23.39 per cent for meat, fish, and poultry. Checked against the Sherman rules that whatever the level of expenditure, at least as much should be spent for each of the two groups milk and dairy products and fruit and vegetables as for meat, poultry, and fish, these diets were above the standard for fruits and vegetables and only slightly below for milk and dairy products. Based on 1928 price indexes, the average cost per man per day of these diets was 41 cents.

Calculated in terms of percentage distribution of total calories, the diets of nearly 50 Utah families were found to be above the standards for milk and dairy products and slightly below for fruits and vegetables.

In a survey of the food habits and hygienic and general nutritive conditions of 359 white and 182 negro children of preschool age in South Carolina, only 60.6 per cent of the white and 49 per cent of the negro children were found to be of normal weight according to the Woodbury height-weight standards. In comparison with an arbitrarily adopted optimum scale for food selection, the diet scores were somewhat higher for the white than for the negro children in milk and eggs, about the same for fruits, and lower for vegetables. In total score the white children averaged only 64.1 and the negro 51.7 per cent. These low scores were attributed in measure to lack of knowledge on the part of the parents of the food requirements of children.

SYBIL L. SMITH.

RURAL HOME MANAGEMENT

Rural home management, although still a relatively undeveloped field of home economics research, is receiving increased attention at the experiment stations. A number of important contributions were made to the subject

during the year, especially with reference to the use of time by farm home makers, efficiency of the household plant, and rural family living.

The use of time by farm home makers.—Results of studies by the Oregon, Rhode Island, and Washington stations and by the Bureau of Home Economics of the Department of Agriculture, where the technic was chiefly developed, have made it possible to compare the time spent in various activities by farm women in different sections of the country.

The average expenditure of time of the 288 farm home makers from whom records were obtained by the Oregon station was 63 hours and 44 minutes per week, of which 51 hours and 34 minutes or 81 per cent of the total time was devoted to home-making activities. The apportionment of this time to the various activities constituting home making was as follows: Food activities, 24 hours and 27 minutes or 47 per cent; care of the house, 9 hours and 9 minutes or 18 per cent; clothing and textiles, 11 hours and 21 minutes or 22 per cent; care of children and other members of the household, 3 hours and 49 minutes or 7 per cent; household management, 1 hour and 39 minutes or 3 per cent of the home-making time.

From similar records obtained from 137 farm home makers in the State of Washington, the average number of work hours per week was calculated as 62.9, of which 53 or 84 per cent were devoted to home making, distributed as follows: Food activities, 50 per cent; care of the house, 16; clothing and textiles, 23; care of family, 5.5; household management, 3.7; and miscellaneous activities, 1.8 per cent.

In Rhode Island 102 records were obtained from farm and rural home makers. These showed an average expenditure by the farm home maker of 58 hours and 35 minutes a week for all household activities, distributed as follows: Foods, 24 hours and 20 minutes; house, 9 hours and 40 minutes; clothing and textiles, 12 hours and 30 minutes; care of the family, 4 hours and 15 minutes; and household management, 3 hours and 20 minutes; not accounted for, 4 hours and 30 minutes.

A comparison of the different items in these three records shows a striking similarity in the distribution of the farm home maker's time. The largest item in all cases is that of food activities, including the preparation of food, setting the table, clearing away

and washing the dishes. Next in order comes what is classified as clothing and textiles, which includes laundry and sewing. The care of the house and sometimes of the grounds about the house occupies nearly as much time, while the time devoted to care of the family members, chiefly the children, and the management of the house seems surprisingly low.

That the distribution of the farm home maker's time among various home-making activities, as shown by these figures, is fairly representative of conditions throughout the country is also evidenced by the similarity in the figures obtained by the Bureau of Home Economics from various sections of the country. A total of 700 records showed the average working time of the farm home maker to be 63 hours and 30 minutes a week, of which 52 hours and 17 minutes were devoted to home-making activities. Itemized figures for 139 of these records obtained from New York State, with an average of 52 hours and 59 minutes spent on all home-making activities, gave a total of 47 hours and 53 minutes devoted to preparing food, caring for the house, and matters pertaining to clothing, while only 2 hours and 26 minutes a week were given to care of children and other members of the family, 1 hour and 47 minutes to purchasing, planning, and other management tasks, and 53 minutes to miscellaneous items. Both the Oregon and Washington stations observed that improved household equipment did not materially lower the amount of time spent on household tasks, but tended to raise the standard of living.

The difference between total work hours and those devoted to home-making activities represents for the most part time spent in farm activities such as poultry, garden and fruit, and dairy work. The average time spent by the Oregon farm home makers in these outside activities was 11.3 hours, and by the Washington farm home makers 9.9 hours per week. Only 63 of the 102 women keeping time records in Rhode Island reported any time given to farm work, the average being 5 hours and 20 minutes a week. Twenty-two women, however, reported other work done for pay. In the Bureau of Home Economics survey an average time of 11 hours and 13 minutes a week was spent on farm activities.

A comparison of the work time of farm home makers with village and urban home makers indicated that the

time spent in purely home-making activities is not appreciably different for the two groups, but that farm activities tend to increase the total time spent at work. The Oregon station observed that time released from home-making activities by various means is likely to be used for increased farm activities rather than leisure, since most farm women find outdoor work interesting.

Efficiency studies of the household plant.—

Investigations in this subject range from a study at the Rhode Island station of the form and proportions giving satisfactory results in household utensils used for pouring and at the North Dakota station of the relative efficiencies of various types of dustless mops to elaborate investigations of the application of electricity in the farm home to cooking, dishwashing, refrigeration, and laundry work. In the development of most of these investigations there has been active cooperation within the stations, chiefly with departments of agricultural engineering.

A survey of types of fuels used for cooking purposes in 1,400 rural homes in Indiana indicated that during the winter months two-thirds of the homes used coal, although only one-third used it as the sole fuel. Wood was used during the winter in half of the homes, one-fifth using it alone and the rest supplementing it with coal or other fuels. Kerosene stoves were used to some extent in one-sixth of these homes during the winter months, and in a larger proportion of the homes during the summer. Gasoline was used as the principal or supplementing fuel during the summer in one-tenth of the homes and gas and electricity in a very few homes. The fuel costs for cooking in 50 rural homes averaged per week 42 cents each for kerosene and gasoline, 92 cents for coal, and \$1.10 for electricity. The time spent in caring for coal stoves was, however, 3 hours and 5 minutes per week as compared with 27 minutes per week for the electric stoves—an illustration of the time-saving value of modern equipment.

Other illustrations of the expenditure of time of farm women in homes without modern equipment are afforded by two studies at the Nebraska station. A survey of 184 homes in eastern Nebraska showed that 50 minutes a week were spent in the care of ordinary kerosene lamps in the households using this type only. It was

found also that the intensity of illumination in homes lighted by kerosene and gasoline lamps was far below the standards set by illuminating engineers.

In the other study it was found that water used for general purposes on Nebraska farms was carried an average distance of 75.7 feet and that used in the laundry a distance of 62.6 feet. The average distance traveled each week in carrying water for household purposes was 4,311.5 feet per home, with an average expenditure of time of 2 hours and 20 minutes a week for general household purposes and 46 minutes for laundry purposes.

A study of electrification in a rural community of 11 homes by the Iowa station revealed the fact that the only use made of electricity in these homes outside of lighting was for electric irons and washing machines. Other appliances were installed in the various homes, and their usefulness, time in operation, and energy consumption were studied. When money was limited the choice of equipment was necessarily the smaller appliances, but when larger sums were available the usual order of choice was lights, washers, water pumping, hand iron, range or range attachment, vacuum cleaner, ironing machine, and small equipment. Dishwashers were thought to be less useful, cost considered, than other equipment because of the care required and the fact that they could not be used for washing cooking utensils or to remove stains made by hard water. Laboratory studies are being conducted at the station to devise a practical electric dishwasher for kitchen utensils. Records obtained in the use of eight electric refrigerators in operation in the rural homes showed an average investment for each of \$345.64 and an average yearly current consumption of 546 kilowatt-hours. A storage space of 1 to 1.5 cubic feet per person was found desirable. Considerable progress has been made at the Iowa station in cooking meat and other materials by means of the heat furnished by the resistance offered by the material to the passage of a current of electricity directly through it.

Other electric equipment studies in progress include a comparison at the Kansas station of the cost of operation, energy consumption, and efficiency of disk and open-coil electric stoves with various types of nonelectric stoves commonly used for cooking

purposes in the farm home; a study at the Maine station of the economic utilization of electricity in food preparation, with particular attention to the changes in cooking processes typical of that section of the country necessary to adapt them to electric cookery, and to the selection of electrical equipment and utensils which will best meet the cooking needs of Maine rural families; and determinations at the Washington station of standards of cooking vegetables in an electric oven.

In connection with the Washington station investigation a mechanical method of determining doneness in cooked vegetables has been devised, involving the use of a penetrating-needle device modified from the Vicet apparatus designed for testing cement pastes. A study by the Washington station of the thermal efficiency of aluminum saucepans of different weights showed that the thermal efficiencies of well-constructed light and heavy cooking utensils are approximately the same and that the extent of evaporation of water from a kettle depends on a well-fitting lid rather than on the weight of the kettle. This suggests that the so-called "waterless cooking" may be accomplished in a light kettle as well as in the much more expensive heavy kettle provided the lid fits well and only sufficient heat is supplied from the heating unit to maintain the desired temperature.

Investigations concerned with the use of electricity in the home laundry plant are in progress at the Washington and Nebraska stations.

Rural family living.—At the close of the fiscal year 1928-29 there were 17 station home economics projects dealing with one or another phase of the question of standards of living. The growing realization that the farm home is an integral part of the farm and that home management and farm management can not well be separated has made it essential to conduct such projects in direct cooperation with farm management projects or in localities where recently collected data on farm management are available.

At the Kentucky, North Carolina, Ohio, and Wisconsin stations standards of living studies are conducted in direct cooperation with the departments of agricultural economics or rural sociology or both. At the Connecticut Storrs station an investigation of the factors affecting the amount and use of family income and

expenditures among a selected group of families in the Eastern Highland is being conducted on the farms included in an investigation of the economic significance of soil types.

At the New York Cornell station an extensive investigation of the cost of living of farm families has been undertaken in accordance with the recommendations of the governor's commission for farm relief and is being supported liberally by State as well as Purnell appropriations. The territory selected for the field survey of about 800 homes is one which is also being surveyed by the department of agricultural economics and farm management and which was surveyed several years ago by the department of rural social organization. It should thus be possible to picture the financial situation of the families studied from all angles.

The technic of conducting cost of living studies has received attention at the Vermont station in a comparison of data on farm-household expenditures obtained by household accounts and by survey. In 13 families supposedly complete accounts of all expenditures were kept for a full year, these accounts being sent in to the station weekly with no attempt on the part of the home makers to summarize the expenditures. At the end of the year the survey method was used with these same women to estimate their expenditures for the year. From a comparison of the data obtained by the two methods and data obtained in another group of the same number of families by the survey method alone the conclusion was drawn that the data secured by the accounting method seemed less accurate as a whole than those secured by careful and detailed questioning. In order to secure accurate account data the necessity was emphasized of constant personal supervision of the accounts, of the use of simple itemized account sheets, and of cooperation on the part of the entire farm family in keeping the accounts.

Two specific studies on cash contributions of farm home makers to the family income are under way—one at Nebraska station and one at Rhode Island station. The Rhode Island study deals not only with the cash contribution to the family income, but with the effect of wage earning on the home maker and on the home and the relation of paid household labor to the freedom of the home maker to do other work.

Since the home maker under modern conditions is primarily a consumer rather than a producer, studies of the purchasing habits and factors influencing consumption of various commodities are particularly timely. One of the few completed and published studies in this field of home management is from the New York Cornell station on sizes of purchasing centers of New York farm families. Practically all of the 325 families included in this study lived on farms in the open country more remote from large than from small centers. These families tended to buy groceries and supplies and the more ordinary articles of clothing in the small centers near home, but to go to large centers at a greater distance for their furniture and furnishings and still farther for the items of clothing about which they are likely to be most particular. Seventy per cent of the entire number of families used mail-order houses to some extent, particularly for clothing, textile fabrics, and sewing machines.

While by no means complete, this report of work in progress in the field of rural home management indicates that a substantial beginning has been made in research along these lines at the State experiment stations.

SYBIL L. SMITH.

AGRICULTURAL ENGINEERING

Continued systematic reorganization of the investigations in agricultural engineering at the experiment stations has gradually led to the formulation of a sound, fundamental program of inquiry.

The facilities provided at the experiment stations for research in agricultural engineering have slowly but steadily expanded during recent years. Nine land-grant institutions have new, modern, well-equipped buildings designed for the exclusive use of the agricultural engineering departments. At several other institutions the agricultural engineering departments have one or more older but substantial buildings for teaching and experimental work, and at least one institution has obtained an appropriation for a new agricultural engineering building. In all these places, however, definite provision is being made for research under the supervision of the experiment station.

Advance in the research in agricultural engineering at the stations is indicated by the numerous reports of results presented in the bulletins and

journals of this department and the stations, and in the publications of the American Society of Agricultural Engineers, the committee on the relation of electricity to agriculture, and the like. While some rather superficial work in agricultural engineering of more or less limited utility is still going on at the stations, much of that now actively carried on is aimed at the development of permanent cost-saving methods and corresponding practical equipment.

MECHANICAL EQUIPMENT

Examination of active projects in agricultural engineering research at the experiment stations indicates that primary emphasis is being given to mechanical farm equipment. Effective investigation in farm machinery, farm power, and related subjects has been urged and materially aided by the advisory council on research in mechanical farm equipment, and the growth of well-directed and effective inquiry into these subjects at the stations is reflected especially in the number of projects operating on the Federal funds and the reports of progress published.

Harvesting machinery.—The experiment stations have recognized the importance of developing more satisfactory and economical methods and equipment for the harvesting of crops. The procedure now most frequently followed calls for the coordination of the forces of agronomy and agricultural engineering in studies of the conditions and requirements for harvesting to provide a sound basis for the proper adaptation of available machines or the development of the principles of new ones to perform this operation satisfactorily.

Considerable investigational work of this character has been in progress at the stations with the combining procedure for the harvesting and threshing of grains and large-seeded legumes, largely in cooperation with the bureaus of this department, for the purpose of exposing the defects in available combine machinery as well as economically performing the necessary operations involved, and of correcting these deficiencies.

The Virginia, Idaho, Pennsylvania, North Dakota, Illinois, California, and Iowa stations have made contributions in this field. The Virginia station has demonstrated the value of shorter cutter bars, stronger reels, and greater

separator capacities to secure all the lodged grain and to cut the full length of straw. The average loss of soybeans has been cut to one-third the original loss, and lower cylinder speeds, with higher separator speeds have been found advisable. The North Dakota station demonstrated that wheat properly combined and stored is equal in quality to wheat harvested with a binder and threshed from the shock, and that the labor involved in combining is only one-fourth that required by the binder-thresher method. Loss of wheat grain in the head was reduced by proper adjustment of cylinders and concaves, and excessive grain cracking was minimized by correcting the clearance between teeth and by reducing cylinder speeds. The California and Idaho stations have both demonstrated the economy and utility of the bulk handling of combined grain and have begun the development of the necessary equipment.

The California station has made advances in solving the problem of harvesting sorghum along cost-saving lines by means of root cutting and combining, demonstrating the superior utility of the general-purpose tractor and of sloping blade attachments to the cutting mechanism for performing the cutting operation with a minimum power requirement.

The practicability of harvesting corn with the combine has been demonstrated by the Iowa station, which has made considerable progress in developing the essential mechanical details. The Ohio station has improved the field silage cutter for harvesting corn so that a much more uniform mixture of silage is provided, and when supplemented by the wagon hoist, a considerable saving of time and labor results.

The Pennsylvania station has reported progress in the development of improved methods and equipment for the harvesting of potatoes, which has already resulted in marked reductions in the labor required in this operation. Harvesting requires more than half the total labor involved in producing the potato crop, and picking up the potatoes by hand requires a third of this labor so that successful efforts to reduce this requirement are of considerable economic significance in potato production.

Unloading hay by the use of slings required only one-half the time taken by the commonly used fork, according to studies of hay-harvesting methods

by the Idaho station. The use of one sling per load for short hauls materially improved the distribution and economy of labor for field and stacking crews, and the utility of the motor-driven mechanical hoist was demonstrated in saving time and improving control.

Crop-drying equipment.—The importance of maintaining superior quality in crops regardless of the harvest conditions has been recognized in studies at the New York Cornell, Wisconsin, Indiana, Nebraska, Louisiana, California, North Dakota, and Pennsylvania experiment stations.

The future of the combine in Pennsylvania, according to the Pennsylvania station, depends largely on the development of suitable equipment for drying the grain before storage, and this view is supported also for other localities by the Kansas, North Dakota, and other stations. The requirements of grain drying for satisfactory storage and of the mechanism of the process for the development of efficient equipment also have been investigated. The Pennsylvania station, in particular, is attempting to develop portable drying equipment to accompany the combine in the field with the purpose of saving time and labor, and the Kansas station has set up extensive equipment for the study of the principles of drying large amounts of grain in storage by natural means at a minimum expense.

The cooperative efforts of the North Dakota station and this department already have resulted in the development of an artificial drying process, using air heated at temperatures as high as 160° F. without injury to the germination, milling, and baking properties of wheat. The cost of the process is small in comparison with the net increase in the market value of the dried grain.

The development of profitable methods and equipment for curing hay artificially has received attention, notably at the Louisiana, Nebraska, Indiana, and Kansas stations, and the Pennsylvania station has recently undertaken a fundamental study of this subject. Artificial drying usually has produced cured hay of rather superior quality quickly and economically, and the efforts to develop efficient drying equipment of high capacity and average cost have been quite successful, especially at the Louisiana station. These investigations have been made more thorough by the coor-

dination of the efforts of agricultural engineers, agronomists, and chemists, and cooperation with bureaus of this department has contributed in no small measure to the progress of these inquiries.

Traction machinery.—The peculiar and often severe conditions imposed upon traction machinery by agricultural draft operations has prompted a number of the experiment stations, especially those in Alabama, Nebraska, Pennsylvania, California, Iowa, Virginia, and Louisiana, to undertake the improvement of traction machinery along specific lines for their better adaptation to agricultural practices.

Special laboratory and field research equipment for studying the principles of traction in difficult soils has been provided by the Alabama station, and laws fundamentally governing the design of tractor wheels and lug equipment which will give maximum tractive efficiency under certain soil conditions already have been developed. The California and Pennsylvania stations have made considerable progress in meeting the emergency conditions imposed upon tractors by the sudden frequent overloads encountered, especially in tillage operations, by modifying and developing such features as hitches, weight distribution, and the like, and by properly balancing the tractor weight and engine power with the resistance of the drawn implements under different soil conditions.

The development of the so-called general-purpose tractor has caused extended inquiry at the Pennsylvania, Louisiana, Ohio, Kansas, Iowa, and Texas stations, with particular reference to its adaptation to the production of row crops. The Pennsylvania station has reduced successfully the expenditure of time and labor required for plowing and seed-bed preparation and also obtained a decided reduction in the labor needed for such operations as drilling grain, cultivating corn and potatoes, mowing hay, and cutting grain. The Texas station found that the cost of producing cotton could be reduced by adapting the general-purpose tractor to bedding and cultivation, and the Louisiana station realized a saving of from 50 to 75 per cent in the labor required in growing corn and soybeans on alluvial soils. Progress also has been recorded in economically adapting the general-purpose tractor to the cultivation of grain sorghums by the Kansas station, the large-scale cultivation of corn by the

Iowa and Ohio stations, and the production of peanuts by the Georgia station. All of these investigations have involved studies of row spacing, clearance, draft, capacities, and the like, and have of necessity coordinated agronomic and agricultural engineering efforts to produce a maximum crop tilled and cultivated at a maximum rate at a minimum expense for labor and power.

Tillage machinery.—Several of the stations have reported progress in reducing the excessive consumption of labor and power in plowing and seed-bed preparation for the production of major crops. Much of the investigation in tillage in the past has been localized, specialized, and superficial, and the necessity for a more complete knowledge of the principles of soil dynamics in relation to the design and operation of tillage implements has led the Alabama station, for example, to establish a research laboratory devoted almost exclusively to the study of soil dynamics as applied to implement design. Provisions for similar work are being made at the Nebraska, Iowa, and California stations, and already much information of practical value relating to the laws of friction between metal surfaces and the soil, to the reactions within the soil to the passage of tillage tools, and to the interrelationships between the factors and variables entering into these reactions has been evolved. These principles can be utilized in improving tillage implements. Efforts to reduce draft by modifying the composition of the metal surfaces of tillage tools to meet the conditions imposed by the physical properties of different soils, for example, were rather successful at the Alabama and California stations, and the Nebraska and New Jersey stations have pointed to the practicability of reducing tillage draft by liming and other soil treatments, and by proper cropping.

The progress made in the development of rotary tillage devices at the Iowa and Indiana stations is also significant with reference to draft power reduction. At the Iowa station especially, a device replacing the moldboard of a standard plow with a revolving pulverizer head has made it possible to plow, beat, and mix the soil into a satisfactory seed bed in one operation, and at the same time to reduce the draft enough to furnish much of the power needed to drive the pulverizer.

The organization of the above investigations without exception is based upon a coordination of the forces of agricultural engineering, agronomy, and soil technology and is aimed at the improvement of tillage methods and equipment along definite cost-saving lines.

Miscellaneous mechanical equipment.—Considerable is being accomplished by the experiment stations in the improvement of such other mechanical equipment as machinery for distribution of fertilizer, feed grinding, orchard spraying, apple washing, corn-borer control, and the like. The bureaus of this department are cooperating effectively in much of this work, particularly in fertilizer distribution and corn-borer control, and the National Association of Farm Equipment Manufacturers, the American Society of Agricultural Engineers, the American Society of Agronomy, and the National Fertilizer Association have actively promoted sound and productive research in these lines at the stations.

RURAL ELECTRIFICATION

The application of electricity to agricultural practices has received considerable impetus at the experiment stations during recent years, largely through the activities of the national committee on the relation of electricity to agriculture, of which this department is a member.

The relatively small number of Purnell projects in rural electrification does not indicate the scope and extent of the work at the stations as a whole. Most of the work has been organized under State committees on the relation of electricity to agriculture, operating under the general direction of the national committee, and the stations concerned usually have found it convenient to cooperate directly with these State committees.

According to the last annual report of the director of the national committee, 24 of the experiment stations are now investigating some 55 problems in rural electrification, those receiving the most attention having to do with poultry brooding, cooking, feed grinding, use of the portable motor, and refrigeration.

While much of this work in the past has been largely of a testing and demonstrational character, the investigations have tended recently to become more specific and technical in order to make possible the more com-

plete and permanent solution of the problems involved. Nineteen stations in the past three or four years have issued some 63 publications containing information of practical utility relating to the use of electricity in dairying, greenhouse crop production, hay handling, household operations, irrigation, poultry production, crop spraying, and water supply.

Poultry production.—The practical utility and economy of electric brooding of young chicks has been demonstrated by the California, Oregon, and Washington stations, and progress has been made in the development of efficient electrical brooding equipment. Electrical incubation also has been placed on a practical and cost-saving basis by the California station, and several stations have demonstrated the profit in increased egg production during the winter months accruing from the artificial lighting of laying houses.

Dairying.—Among others the California, Missouri, and New Hampshire stations have developed successfully the profitable use of electricity in dairy refrigeration. The California station also demonstrated that a large electrically heated steam cabinet produces good bacterial reduction in dairy utensils and that the heating is rapid enough for practical purposes. Similar results were obtained by the Oregon station, and a satisfactory electrical water heater for dairy use was also developed. The New Hampshire station also reported some success in the development of the process of precooling milk to produce a better product, and some success has been attained in the ultra-violet ray treatment of milk.

Hay handling.—The Oregon and Washington stations have proved the practical value and economy in time and labor of electrically operated hay hoists and have established the specifications for satisfactory equipment. Equipment has been developed which will handle hay at as low a cost as 1 cent per ton at a rate of 3 cents per kilowatt hour.

Home refrigeration.—Studies to develop efficient home refrigeration practices and equipment have been in progress at several stations. The New Hampshire, Alabama, and South Dakota stations, especially, have been successful in securing useful information as to the economical operation of electrical refrigeration plants with special reference to various food products. Distinctly superior refrigeration has been obtained by the electrical method

over the ice method, and at a reduced cost.

Use of small electric motors.—The Pennsylvania, Michigan, Washington, Nebraska, Wisconsin, Illinois, Iowa, Missouri, and Oregon stations have reported success in the economical and practical adaptation of small electric motors to different farm belt-power operations. Silage cutting and blowing, feed grinding, threshing, machine milking, cream separation, pumping, wood sawing, and the like have been accomplished by electricity, with greater convenience and economy of time and labor. It has been possible to cut and elevate silage, for example, with a 5-horsepower motor when properly adapted, and a 10-horsepower motor has been found to furnish sufficient power to operate a small threshing machine.

Unit electric plants.—Several of the experiment stations, notably those in Nebraska, Missouri, and Michigan, have established the economic importance of increasing the number of uses of electricity from a single isolated plant, as this practice apparently does not shorten the life of the batteries. In general the unit plant has been found to furnish sufficient energy for lighting and for operating small motors and appliances although the cost of such energy exceeds that of current supplied from central station plants.

Experimental power lines.—The majority of the experiment stations engaged in rural electrification studies are working in cooperation with experimental power lines established by the State committees on the relation of electricity to agriculture, or by the national committee. These lines constitute a vast experimental laboratory on which the research findings at the stations can be subjected to rigid practical and economical test. The Maryland station, for example, is cooperating with a national rural electric project located in the State, the chief features of which are research and investigation. The importance of this type of research and investigation at the stations is reflected in the recent report by the national committee that the farms in the United States with electric service number well above 800,000.

LAND RECLAMATION

Research in land reclamation at the experiment stations, including soil-erosion prevention, water conservation, irrigation, drainage, and land clearing, has received considerable impetus re-

cently, especially in some of its more fundamental aspects. This movement has been largely on account of the evident necessity for greater economy and efficiency in the methods and permanency in the structures and equipment used. The research program of the experiment stations includes 16 Purnell projects and 5 Adams projects on different phases of the subject, and extensive investigation supported from other sources also is active at the stations. The fact that the greater part of the work is also cooperative with various bureaus of this department has made much of it of national importance.

Prevention of soil erosion and conservation of moisture.—Station research on soil-erosion prevention and moisture conservation in the past has consisted largely of the testing of terraces of various widths, heights, and grades, without adequate consideration of the characteristics of the soils involved, or of the most suitable cropping practices. Thus the work has been frequently overspecific, superficial, and of limited utility.

A recent movement which is indicative of the trend toward more fundamental research in land reclamation calls for the development by the United States Department of Agriculture of a national program for the control of soil erosion and the setting up of erosion-prevention and moisture-conservation stations on 18 erosion areas throughout the country under a congressional appropriation of \$160,000. A number of the experiment stations are cooperating in the project.

The Texas and several other stations have set up extensive field and laboratory equipment to study the soil factors involved in erosion and moisture absorption. The apparatus includes run-off plots with various grades, conditions of tilth, and coverings, and catch basins to determine the amount and character of eroded material and run-off water. The purpose of these studies is to identify the factors governing erosion and run-off in different soils and to develop methods and practices for control which will meet the characteristics and requirements of individual soils and crops. The large amount of information already obtained is serving as an admirable basis for the more fundamental studies.

Among examples of the work is the finding of the Oklahoma station that

with terraces of the conventional type with variable grade and open outlets the total quantity of run-off will increase as the vertical interval is decreased but the quantity of soil eroded will be slightly less. The Texas station points to the physical condition of the soil and the rate of rainfall as the important factors in run-off, and it appears that the greatest beneficial results from water-conservation measures can be secured at a minimum cost on comparatively level land. In fact, the Indiana station found no visible erosion in the flow lines of Mangum terraces having a grade of 0.6 per cent or less. Since buffalo grass appears to be the most effective crop in preventing water losses, overpasturing evidently is a bad practice.

The Missouri station has determined the practical value of plowing in and seeding gullies and has found that bluegrass sod placed in old burlap bags and straw are cheap and effective materials for use in stopping small washes in wheat fields, meadows, and pastures where the slopes are moderate.

Irrigation.—Realizing that irrigation is responsible for a large part of the total cost of agricultural production, the experiment stations in the arid and semiarid regions are demonstrating that maximum economy and effectiveness of irrigation methods and equipment are of great importance. Superficial tests of duty of water, for example, are no longer considered adequate and are being replaced by more fundamental studies to develop more precise and economical methods of using water, based upon the requirements of specific crops and soils. The attack on current problems calls for the coordination of the efforts of the engineer and agronomist. The fact that many of the irrigation investigations at the stations are in cooperation with the Department of Agriculture has aided considerably in the organization and conduct of the work and in the provision of special research equipment.

In the course of irrigation investigations, the Idaho station established a mathematical expression for the flow of water in thin sheets through silt loam soils, thus aiding materially in the more economical application of irrigation water to such soil types. In reporting further progress in determining the principles governing the loss of irrigation water from different soil types by evaporation, the Colo-

rado station pointed out especially that light showers may cause a more rapid depletion of the moisture already in a soil because the cooling of the soil by the rain increases the surface tension of the capillary moisture drawn up from the water table. This result is of significance in connection with light or infrequent irrigations. The Washington station has established the limiting time interval and depth of irrigation for alfalfa, and together with the California station, has demonstrated the value of the wilting point in soils as an indicator of the irrigation required for corn and certain fruits.

Irrigation water supply.—The stations in the irrigated sections have made progress toward the solution of the serious problem of securing more adequate supplies of water to meet the needs of irrigation. The Utah station found that snow cover outweighs all other factors in its effect on stream run-off and that the soil must be saturated with snow water before run-off begins. Since the water passes through the snow and saturated soil into the streams, no dependence can be placed on feeder ditches to intercept snow water unless they actually cut across the line of flow through the soil.

In connection with the rapid settlement of certain localities, the Utah and Nevada stations have obtained evidence that the annual pumping must be reduced in some places because the surrounding watersheds are unable to maintain the underground supply. The possible contingency of a lack of available water for indefinite periods has thus been averted. Such findings are contributing in no small measure to the development of rational practices in irrigation in certain of the arid localities.

Drainage.—The formulation of more fundamental conceptions of the problems of drainage also seems to have assumed an important part of the work by the stations in the subject. The Minnesota, Utah, California, and Washington stations are seriously considering the principles of groundwater movement under drainage, and in some cases they are receiving the cooperation of this department. The Utah station has made some progress in the drainage of irrigated lands overlying artesian basins, and already has evolved a theoretical physical basis for this practice. In studies of groundwater movement in alkali soils, the

Washington station found that part of the drainage and underground water from alkali areas comes from sources other than through the upper layers of the soil.

Land clearing.—Progress in land-clearing investigations at the stations is evidenced, for example, by research at the Minnesota and Alabama stations, which has evolved mathematical formulas governing the procedure used in blasting stones from soils and in stump blasting. The Minnesota station also has demonstrated the superiority of the dump wagon over other vehicles used in the transportation of stones, and has obtained data on the cost of clearing land of stones by different methods.

STRUCTURES

Until quite recently, the work in farm structures at the experiment stations was limited largely to surveys of existing structures and the execution of new plans incorporating the best available features, without adequate consideration for the actual requirements to be met. The stations and this department now recognize that proper housing is a factor of paramount economic importance in the animal, dairy, poultry, fruit, and vegetable industries, and that investigations coordinating engineering technique with the different agricultural sciences are needed to establish and fully meet agricultural housing requirements. The advisory council on research in farm structures, recently appointed by the Secretary of Agriculture, to survey, clarify, and define the field of research in this field already has acted as a powerful stimulus to the work at the experiment stations.

Poultry structures.—The practical significance of the investigations of the housing requirements of poultry for maximum economic production is exemplified by the finding of the Nebraska, Iowa, and Indiana stations that temperature uniformity is the prime factor in the health and productiveness of poultry, and air purity and humidity are secondary in importance. The Ohio, Idaho, Iowa, New Jersey, and other stations also have developed poultry houses economical in construction and saving in time and labor in tending the poultry.

Animal and dairy structures.—The necessity for economy, as well as efficiency in barn design and construction has been shown in the investigations of

masonry-arch barns which has been carried on at the Iowa station for several years. Under favorable conditions the cost of such a permanent structure will be only 25 to 50 per cent more than that of wooden construction of limited durability. A unit-space method of barn planning developed by the Arkansas station provides for considerable economy in construction and introduces efficiency into the performance of the chores.

Studies on the planning of dairy barns from a manufacturing point of view at the Wisconsin station showed that the average of 100 barns provided 50 per cent of the floor space for the convenience of the man doing the chores. The total route distance per cow required for chores and the milking operations favored the face-in arrangement of stalls, and the route distance per cow was found to be nearly 19 per cent greater for the crosswise than for the lengthwise arrangement.

That sanitation and cow comfort also are important factors has been brought out in studies of dairy-barn floors at the Iowa and Kansas stations. The Iowa station has demonstrated the superior wearing qualities of concrete and rubber-block floors and the insanitary quality of wood-block floors. At the Kansas station solid-concrete floors compared favorably in regard to temperature during the winter with floors constructed of building tile between two layers of concrete. Two-inch plank floors, cork brick, creosoted pine, and creosoted block warmed up much more rapidly than concrete, indicating the superior heat-retaining properties of the wood and cork.

Crop storage.—In the past the practice in the development of storage structures often has been to simply build a structure, to store several different types of fruit and vegetables therein, and to accept a certain percentage of loss. Recent investigations indicate the possibility of minimizing the losses and of also avoiding the intangible but appreciable nutritive and culinary deterioration occasionally encountered under certain conditions. The Maryland station found that 40° F. is the best storage temperature for potatoes, while from 32° to 35° F. is the best storage temperature for carrots, indicating that storage conditions suitable for one vegetable may not suffice for another.

A number of stations are attempting to meet the very evident need for

information on the storage requirements of each fruit and vegetable. Results obtained at the Massachusetts, Pennsylvania, Iowa, and Indiana stations with apples, and at the Georgia and New Jersey stations with sweet-potatoes have been of fundamental value in securing higher quality in these commodities at a lower cost. The Pennsylvania findings, in particular, have indicated practical methods for insulating fruit and vegetable storages to secure the optimum interior conditions during winter. It has been found that frost-proof storages may be easily and economically constructed when the heat given off by the ground during the winter is properly utilized.

Farm dwellings.—Greater economy and utility in the construction of farm dwellings is a profitable field of research. The minimum cost for two to four room houses of fair construction without basement or utilities, according to the Arkansas station, is almost 12 cents per cubic foot, and with increase in volume the cost per cubic foot is higher. Apparently more attention should be given to the 1-story house, larger kitchens, fewer and larger rooms, smaller total area, more work-porch area, and direct entrance to the kitchen from the outside.

Materials of construction.—The development of cheaper methods and more durable materials of construction has received some attention at the stations. The California and North Dakota stations and this department have made considerable progress in the development of adobe and rammed earth as structural materials for farm out-buildings, and several other stations, including especially the Iowa, Pennsylvania, and Arkansas, have demonstrated the economy of protecting the wooden timbers of farm structures against decay by various preservative treatments. The Forest Service of this department has cooperated effectively in this work to the end that considerably longer and better service can be secured from wooden structures.

Farm sewage disposal.—Greater comfort, convenience, and sanitation in the farm home at minimum cost are recognized now as important economic features of the modern farm home. Progress in the attainment of these has been realized from the studies at such stations as the Kansas, Illinois, Montana, and Wisconsin, all of which have resulted in information relating to size, construction, and cost

of sewage-disposal systems adapted to farm homes of different sizes.

ROBERT W. TRULLINGER.

AGRICULTURAL ECONOMICS AND RURAL SOCIOLOGY

The more recent recruits to the cause of agricultural research, economics and sociology, made a satisfactory showing during the year. Improvements were made in station personnel, projects, publications, and co-operative relations. The number of persons employed in agricultural economics increased from 229 to 234. The number of specialists in this field holding master's degrees increased from 112 to 125, and the number holding doctor's degrees increased from 43 to 52. The number of specialists in rural sociology increased from 27 to 32, the number holding master's degrees from 8 to 11, and the number holding doctor's degrees from 7 to 14. As the proportion of persons holding the higher degrees increased, those holding bachelor's degrees only or no degrees at all declined correspondingly.

Though the number of active projects in agricultural economics and rural sociology increased only slightly during the year, definite improvement was noted in the character of new projects undertaken and older ones revised. Of the total number of economics projects under way, about 40 per cent dealt with various phases of farm management, and about 45 per cent dealt with marketing problems. The remaining economics projects were concerned with taxation, farm finance, and land utilization. In sociology, emphasis was placed upon rural social organization, although a growing interest in the study of rural population and standards of living was evident. In both economics and sociology, significant progress was noted in cooperation and coordination of research effort. The number of cooperative projects in these two fields increased from 208 in 1927-28 to 299 in 1928-29.

The station publications received during the year reveal the widespread interest in agricultural readjustment, which has arisen out of recent experience with unprofitable surpluses. Out of a total of 109 bulletins reporting results of economic studies, 47 were upon marketing and 28 were upon farm-management subjects. Although 16 bulletins were reports upon surveys of areas, enterprises, and farm com-

modities, it is evident that agricultural surveys are either giving way to more clear-cut methods of economics research or becoming incidental to them. Only 3 bulletins were published on the agricultural outlook. Ten bulletins dealt with agricultural taxation, 3 with farm finance and rural credits, and 2 with land economics. Thirteen bulletins carried the results of rural sociological studies.

Judging from the evidence at hand, the stations are seriously endeavoring to contribute their part to the solution of the problems of agricultural readjustment. These problems may be divided into two rather distinctive but mutually interrelated groups. The one dealing with the prices received by the farmers may be classed as marketing, and the other, concerned with the size and quality of the supply and the expenses involved in production, as farm-management problems. Specialists and administrative leaders evidently realize that what the growers are striving for is not prices only but profits and incomes; that these ends are to be realized by the reciprocal processes of increasing receipts on the one hand and curtailing operating expenses on the other. The researches in marketing are designed to yield information which will enable the growers to eliminate inefficiencies and unnecessary costs in moving commodities from the farm to the centers of consumption and to encourage demand, and thus to maintain satisfactory price levels. Concurrent with marketing studies, researches in farm management and related economic inquiries are designed to yield information which will enable the growers to organize and operate their farms in such a manner as to produce the necessary supplies of farm commodities at costs consistent with prices received. Progress in the solution of these two groups of economic problems is indicated by a few examples of results reported during the year.

MARKETING

In a study of the relation of the grade and staple length of cotton to the prices received by growers in their local markets the Texas station gathered a total of 2,518 samples, including 408 at Robstown, in south Texas, 938 at Henderson, in east Texas, 478 at Hillsboro, in the black waxy prairie belt, and 694 at Lubbock, in the new cotton-growing area of west Texas.

The model quality was Middling White 15/16-inch cotton; and the modal grade at Robstown, Henderson, and Hillsboro was Middling White, whereas at Lubbock it was strict Low Middling White cotton. The weighted average staple length was 13.95 sixteenths inch at Henderson, 15.15 at Lubbock, 15.63 at Hillsboro, and 16.03 at Robstown. Although a tendency was noted to pay for cotton at each point studied on a basis of average quality, there was only a slight tendency to recognize grade differences and values. Very little, if any, recognition appeared to be given staple length in determining the price paid to the cotton grower.

In a comparison between local and central market values, grouped according to grade regardless of staple, it was evident that the low grades had been recognized and penalized in the local buying. The higher grades seem to have been bought on a flat or average basis and consistently penalized. There was no evidence of a conscious effort on the part of local trade to reward long staple or to penalize short staple. It is becoming quite generally recognized that this type of buying encourages farmers to plant varieties that will give them the highest yield regardless of staple quality, which seems to explain the decline in the spinning value of Texas cotton. The results of a similar study by the Alabama station tend to confirm the Texas findings.

The Ohio station, in a study of direct-to-packer buying of hogs in the United States in 64 middle western markets extending from January, 1920, to June, 1928, inclusive, found that the percentage of hogs purchased direct increased from 20.2 in 1920 to 32.4 in 1927. Ordinarily the greater percentage of the total number slaughtered was purchased direct during the months of October to February, inclusive. The data indicated that packers increase the proportion of direct purchases during periods of increase in the hog-marketing cycle, hold or slightly decrease the percentage with the peak of the cycle, hold about the same proportion during the period of decrease in receipts, and increase the proportion during the next period of increasing receipts.

In a study of cooperative butter marketing, the Wisconsin station secured data upon 182 or 64.3 per cent of the cooperative creameries of the State. Of these, 46 graded cream, but only 31

paid on a grade basis, though 16 of this number were in a cooperative sales organization. Of the butter of the creameries in two counties selling cooperatively, 81.5 per cent was 93-score sweet cream in 1925 and 90.8 per cent in 1927. A comparison of the groups making from 150,000 to 450,000 pounds of butter per year and 1,350,000 pounds and over showed that in 1925 the hauling of cream per pound of butter cost, respectively, 1.46 and 1.125 cents, and butter making, 3.055 and 2.107 cents. The net prices received were 43.337 and 43.383 cents, and the prices paid for butterfat were 49.513 and 51.847 cents, respectively. The advantages to producers increased according to the size of the creamery. Fourteen federated creameries received from 0.647 to 1.333 cents per pound more for butter and paid from 0.814 to 1.695 cents more for butterfat than did four other groups of similar number and size.

Cooperative marketing.—Of the 47 bulletins received during the year on marketing subjects, 7 dealt rather specifically with cooperative marketing. The Iowa station reported results of a follow-up study of one previously made on the subject of local cooperative livestock associations in Iowa since 1920. Between the two studies the number of cooperative shipping associations increased. In 1924, about 50 per cent of the farmers of the State were using such associations to a greater or lesser extent, but the proportion of total shipments handled by the associations remained practically the same. In 1925, 68 per cent of the associations were incorporated, as compared with 34 per cent in 1920. Incorporated associations shipped on an average 105 cars of livestock as compared with an average of 92 cars shipped by unincorporated associations. The manager-controlled associations shipped an average of 135 cars, while those in which managers had no control of shipments averaged only 71 cars. Changing conditions in the livestock trade, such as the expansion of the demand of local packers and trucking to markets, were found to be testing severely the efficiency of the management of the shipping associations.

The North Dakota station found that the average costs of marketing for 80 cooperative associations selling livestock in the South St. Paul market in 1927 were for cattle, 70.27 cents per hundredweight; for hogs, 79.98 cents; for sheep in double-deck cars, 88.19 cents; for sheep in single-

deck cars, 120 cents; and for mixed cars, \$1.36 cents. Of the average costs of marketing, freight amounted to from 50 to 55 per cent; selling commissions, to from 10 to 15 per cent; and all terminal charges, including freight, to from 80 to 85 per cent of the total marketing costs. Out of each dollar of gross sales, the cooperative associations in 1927, on an average returned to members for cattle, 89.4 cents; for hogs, 92.9 cents; for sheep, 91.9 cents; and for mixed shipments, 90 cents.

Interrelations of supply and price.—Illustrative of the improved technic employed in modern price analysis, the New York Cornell station reported the results of a statistical study of the interrelationships of supply and price of farm products. The clarity of conclusions drawn by the project leaders should be helpful to those who would give meaning to the commonplace expression "changing economic conditions."

Attention is called to the error of using wholesale prices as measures of consumers' and producers' prices. It is stated that the price that the producer receives is the only price that affects production and that the price that the consumer pays is the only price that affects his consumption.

Distinction is made between the particular prices which affect different parts of the supply consumed. That part used on the farms is affected by farm prices, which fluctuate violently; that part of the supply consumed which sells at retail is affected by retail prices, which fluctuate little; that part of the supply consumed which sells in tin cans is affected by prices of canned goods, which fluctuate still less; and that part of the supply consumed in hotels is affected by prices on the bill of fare, which are practically indifferent to supply.

The authors qualify the statement that supply and demand govern prices. Not all prices may be thus fully explained. Consumers' prices are governed by supply and demand. Prices paid to farmers are consumers' prices less the cost and profit of distribution. They may be low because supply or demand has made them low, or they may be low in spite of high consumers' prices if distributing charges have risen.

In May, 1927, food products sold by American farmers were retailing in American cities for 72 per cent above pre-war prices, but farmers were re-

ceiving only 46 per cent above pre-war prices for them. Distributing charges for farm products in 1927 averaged 91 per cent above pre-war charges. This made farm prices low.

The producer pays the freight and all other distributing costs until such a time as he is able to reduce production and so pass on a part of these charges to the consumer. Consumers pay more for a large crop than for a small one. Farmers receive fewer dollars for a large crop than for a small one. The extra amount paid by consumers remains in the cities.

Farmers respond to prices as vigorously as does industry, but they are dealing with biological facts. When prices of pig iron were 20 per cent above normal, production was increased 12 per cent in the same year. When round steak sold for 20 per cent above the normal price, the receipts of steers in Chicago were increased 32 per cent eight years later.

Though authorities may differ in the interpretation of marketing phenomena, studies of this character tend to promote a clearer appreciation of the practical problems of agricultural readjustment.

FARM MANAGEMENT

In the bulletins received a growing appreciation is noted of the importance of clearer pictures of type-of-farming areas as bases for intensive studies of farm organization and operation. A typical example of the results obtained from study of type-of-farming areas was reported by the Iowa station. The five type-of-farming regions studied were the cash-grain area in the central and northwestern part of the State, the dairy area in the northeastern part, the western meat-production area, the eastern meat-production area, and the southern pasture area. In four of these areas livestock and livestock products are the principal sources of income. In the cash-grain area, a large part of the receipts comes from sales of grain. In the dairy area, receipts from the sale of butterfat are of primary importance. In the other three areas, hogs and beef cattle are the chief sources of income.

Two groups of conditions and forces determine the prevailing types of farming in the five areas: (1) The economic forces, centering in prices and costs, and (2) the physical, or natural conditions, including soil, climate, and surface or topographic fea-

tures. Changes in economic forces effect changes in the type of farming. The particular types of farming of each area are accounted for largely through the peculiar combination of soil, surface, and temperatures and rainfall and their distribution. It is pointed out that these influences first determine the cropping system, and this in turn determines the livestock system of each area.

Corn is Iowa's leading crop, one-third of the area of the State being devoted to it. Oats are next in importance, occupying about 18 per cent of the area of the State or a little more than half the grain acreage. Wheat is grown but occupies only about 1.1 per cent of the farm land. Hay is relatively unimportant except in the dairy and eastern meat-production and southern pasture areas. Hogs constitute the most important type of livestock enterprise. Fully 40 per cent of the Iowa farmers' income is normally derived from the sale of swine. Next in importance comes the selling of beef cattle; then follow dairy cattle, poultry, sheep, and work stock in descending order of importance in their commercial production.

From the results of the more intensive studies which follow the check-up on types of farming, it is hoped that the agriculture of Iowa may be kept in adjustment with its natural setting on the one hand and with changing economic conditions on the other.

Ranch management.—The stations' interest in readjustment has not been confined to the farming section alone, as evidenced by the bulletins received on ranch organization and management. The Colorado station, in a study of 32 cattle ranches in the mountain area of the State, covering the period 1922 to 1925, found that the size of herds varied from 162 to 2,618, averaging 1,800 head. The ranches varied in size from 860 to more than 55,000 acres, two-thirds of which was owner operated. The average investment was over \$100,000, of which more than one-third was in cattle. Only two ranches were free from debt. Cattle debts amounted to about \$18 per head and 40 per cent of the total indebtedness.

The average return was 2.74 per cent, or about \$2,000 on total investment. The ranch expense per head amounted to \$10.32, excluding interest, and \$18.38 including interest on investment at 6 per cent. Total ex-

penses averaged \$10,781. The largest item, \$4,187, was for paid labor, the next largest was \$1,091, for taxes, and the next was \$973, for feed and salt. Cattle gained from 200 to 250 pounds a year. From 1,100 to 3,300 pounds of hay per cow was fed, depending upon the severity of the winters. No grain was fed to cows. The percentage of calf crop varied from 39 to 91, averaging 64. Calf crop was 11 per cent higher on fenced ranges than in national forests. One dollar's worth of extra grain per bull secured a 9 per cent increase in calf crop. Private lands, public domain, and national forests were used. The principal problem before the ranchman, the reduction of operating expenses to an item consistent with normal receipts, called for stricter economies in ranch operation, greater skill in handling cattle on the ranges, and the combination of other enterprises with cattle.

The Nebraska station published the results of study of the economic aspects of the cattle industry in the sand hills area. The land of the area is utilized very largely for grazing. The average investment in the 47 ranches studied was approximately \$70,000. The average size of the ranches was 6,681 acres. Average cash receipts varied per ranch from \$6,577 in 1924-25 to \$11,837 in 1926-27. Average cash expenses varied from \$3,809 in 1924-25 to \$4,328 in 1926-27. The average return on investment on owner's equity varied from 0.5 per cent in 1924-25 to 8.8 per cent in 1925-26 and 5.4 per cent in 1926-27. Cattle were the principal source of income. Hired labor was the most important item of expense, averaging one-third of all current cash expenses, interest excluded. It was found that individual ranchmen varied greatly in their ability to interpret market conditions and adjust their production plans with profit to themselves.

A number of States reported results of studies of taxation, credits, and land utilization, which may be interpreted as a manifestation of their interest in efficiencies and economies in production as partial offsets to existing low prices.

RURAL SOCIOLOGY

A comparative study of incomes and expenditures of 226 farm and 252 city families by the Minnesota station revealed that the average cash receipts per farm family amounted to \$3,647, an average per adult of \$954, and the

average of cash receipts ranged from \$836 for 14 families to \$10,563 for 26 families. The expenditures were greater than farm receipts. The average farm family expenditures totalled \$3,951, of which \$1,733 was spent on the farm; \$848 was invested; \$248 was spent on automobiles; and \$1,122 was spent on the family living.

The average income of urban families totalled \$3,878 and the average expenses, \$3,943. Net spendable incomes distributed into groups increasing in size by \$1,000 to \$6,000 or more showed that the higher the net spendable income, the lower was the proportion used for living and the greater was the proportion devoted to investment, including interest payments. As incomes increase certain principles seem to govern the distribution of expenditures among the urban families studied. The consumption of all items increases in quantity and value. Proportionately, food, household, clothing, and health expenditures decline. Miscellaneous or "advancement" expenditures remain about constant, although they show some tendency to increase proportionately in the middle groups. Proportions used for automobiles increase, but those for investment increased most rapidly of all.

Competition within the family budget is indicative of the attitude of families toward improved living. Expenditures for present consumption compete with those looking ahead to the future, investments for example.

The author recognized the difficulties of attempting to make fair comparisons between city and farm incomes. The distribution of expenditures shows an average of \$1,193 per city adult and only \$640 per farm adult unit. Although city dwellers have certain definite advantages not enjoyed in the rural districts, farm families enjoy certain material and inspirational values not available to city dwellers. For example, farm cash income is supplemented by many living items such as food, house rent, and fuel directly appropriated from the farm. Generally speaking, the relative standards of living of farm families, as compared with those of city families, have been greatly underestimated. This study makes an important contribution towards the development of a satisfactory basis of comparing city living incomes with those of the rural districts.

A study in 1926 of living conditions among white owner operators in Wake

County, N. C., by the North Carolina station, included 294 white farm land owning and operating families, or 14 per cent of the total white family owner operators in the county. The average age of the operators was 50 years; total acres owned, 58; acres in crops, 30½; size of family, 4.6; length of experience of operators, 28 years. Of the operators studied, 61 per cent were born in the township, 76 per cent in the county, and 98 per cent in the State. Of the total cash income, 64 per cent came from crops—principally cotton; 7 per cent from labor; 13 per cent from animals; and 16 per cent from investments. The average expenditure for all items in the living budget was \$1,056, or 44.3 per cent of the total expenditure budget. Home and household expenses took 16.5 per cent; food and fuel, 15.6 per cent; clothing, 27.8 per cent; automobile, 12.6 per cent; health, 7.8 per cent; education, 5.5 per cent; reading, 1.2 per cent; social activity and recreation, 0.9 per cent; other items, 12.1 per cent. The low farm incomes and living standards of Cotton Belt families revealed in this investigation suggest the need of further and more profound study of the subject and of the economic problems of readjustment.

Community halls and libraries.—A study of rural community halls was reported by the Montana station. More than 100 rural communities in that State have built social halls since 1893. These halls serve as centers for a wide variety of educational, social, religious, and economic activities. When properly maintained, the halls promote community solidarity, increase neighborliness, provide recreation, and are the source of many cooperative undertakings.

The Montana station also reported a study of county libraries. In 1915 the Montana Legislature enacted a law authorizing counties to levy a tax not to exceed 1 mill for libraries. Nine of the 56 counties now maintain libraries. About 35 per cent of the population of the counties having libraries are registered as patrons. Borrowers are about equally distributed as between young people and adults. Average total circulation for all nine county libraries was 28,341 volumes. Circulation is facilitated by 277 book stations in schools, 5 branch libraries, and 79 book-deposit stations. About 44 per cent of the books are fiction; 28, reference; and 28 per cent juvenile.

Rural supplies and services.—The Minnesota station reported analyses of the distribution of supplies and services among the farm population. The study represents the buying side, as contrasted with the selling side, of the farm family. Towns from 300 to 12,000 population in agricultural districts were selected for study. The report states that from practically every standpoint the fates are against the small trade center, and slowly but surely, a new type of trade center in rural regions is developing. The advent of good roads and automobiles has made it easy for the farmer to go considerable distance for commodities that were formerly purchased in his near-by trade center. Farmers are now purchasing commodities in the larger trade centers, where special

stores are found, whenever it is desirable to look over larger assortments than are carried by the stores in the small trade centers. The small trade center does not thoroughly serve the modern farmer who is scientific in his agricultural practices. The modern farmer wants something more than coffee and flour. He wants association and ideas. The study showed that the general store and small trade centers are maintained at a degree of waste to the community. The average mark-ups on goods were higher in the small centers than in the larger ones. Nearness and convenience are the only advantages of the small trade centers. A closely related study of village service agencies was reported by the New York Cornell station.

B. YOUNGBLOOD.

PUBLICATIONS OF THE STATIONS (1928-29)

The following list of regular publications of the stations received by the office during the year ended June 30, 1929, includes 751 publications classified as follows: Meteorology, 14; soils and fertilizers, 63; field crops, 72; horticulture, 77; forestry, 8; plant diseases, 53; entomology, 56; foods and human nutrition, 10; animal production, 65; dairying, 39; diseases of livestock, 27; agricultural engineering, 27; economics, 104; sociology and home management, 16; and reports, periodicals, regulatory, and miscellaneous publications, 120.

In addition to their regular bulletins and reports, the stations published 2,000 articles relating to their work in 77 outside journals. They also contributed or collaborated in 44 articles published in the *Journal of Agricultural Research*.

The amounts reported as expended for publications by the experiment stations during the year were as follows: Hatch fund \$21,042.11, Purnell fund \$51,454.51, State funds \$275,078.43, total \$347,575.05. The amount used from the Federal funds was 20.85 per cent of the total amount expended for publications.

METEOROLOGY

- The climate of Colorado, a forty-one year record. R. E. Trimble. Colo. Sta. Bul. 340, 68 p. 1928.
- The climate of Florida. A. J. Mitchell and M. R. Ensign. Fla. Sta. Bul. 200, p. 91-300, illus. 1928.
- The relationship of weather to crops in the Plains region of Montana. P. Patton. Mont. Sta. Bul. 206, 66 p., illus. 1927.
- Meteorological observations. C. I. Gunness et al. Mass. Sta. Met. Buls. 475-485, 4 p. each. 1928-1929.

SOILS—FERTILIZERS

SOILS

- The use of alcoholic salt solutions for the determination of replaceable bases in calcareous soils. O. C. Magistad and P. S. Burgess. Ariz. Sta. Tech. Bul. 20, p. 481-497, 1928.
- Soil zeolites and plant growth. J. F. Breazeale. Ariz. Sta. Tech. Bul. 21, p. 499-520, illus. 1928.
- The hydrolysis of sodium and potassium zeolites, with particular reference to potassium in the soil solution. O. C. Magistad. Ariz. Sta. Tech. Bul. 22, p. 521-547, illus. 1928.

- Base exchange in orthoclase. J. F. Breazeale and O. C. Magistad. Ariz. Sta. Tech. Bul. 24, p. 607-629, 1928.
- Plant and soil relations at and below the wilting percentage. O. C. Magistad and J. F. Breazeale. Ariz. Sta. Tech. Bul. 25, 36 p., illus. 1929.
- Magnesium and calcium in zeolitic soils. J. F. Breazeale. Ariz. Sta. Tech. Bul. 26, p. 37-65, illus. 1929.
- The chemical effect of gypsum, sulfur, iron sulfate, and alum on alkali soil. W. P. Kelley and A. Arany. Hilgardia [Calif. Sta.], vol. 3, no. 14, p. 393-420, 1928.
- Boron in the soils and irrigation waters of southern California and its relation to citrus and walnut culture. W. P. Kelley and S. M. Brown. Hilgardia [Calif. Sta.], vol. 3, no. 16, p. 445-458, 1928.
- Changes in the nitrate and sulfate content of the soil solution under orchard conditions. E. L. Proebsting. Hilgardia [Calif. Sta.], vol. 4, no. 2, p. 57-76, illus. 1929.
- Daily and seasonal air and soil temperatures at Davis, California. A. Smith. Hilgardia [Calif. Sta.], vol. 4, no. 3, p. 77-112, illus. 1929.
- Root development and soil moisture. J. P. Conrad and F. J. Veihmeyer. Hilgardia [Calif. Sta.], vol. 4, no. 4, p. 113-134, illus. 1929.
- Reclamation of the Fresno type of black-alkali soil. W. P. Kelley and E. E. Thomas. Calif. Sta. Bul. 455, 37 p., illus. 1928.
- Reaction studies of Delaware soils. C. R. Runk. Del. Sta. Bul. 155, 17 p., illus. 1928.
- A type of bacteria abundant in productive soils, but apparently lacking in certain soils of low productivity. H. J. Conn. N. Y. State Sta. Tech. Bul. 138, 26 p., illus. 1928.
- Relation of the water-soluble potash, the replaceable, and acid-soluble potash to the potash removed by crops in pot experiments. G. S. Fraps. Tex. Sta. Bul. 391, 18 p. 1929.
- Crop yields from Illinois soil experiment fields in 1928. F. C. Bauer. Ill. Sta. Bul. 327, p. 211-238, 1929.
- Whiteside County soils. R. S. Smith, O. I. Ellis, E. E. DeTurk, F. C. Bauer, and L. H. Smith. Ill. Sta. Soil Rpt. 40, 65 p., illus. 1928.
- Henry County soils. R. S. Smith, E. E. DeTurk, F. C. Bauer, and L. H. Smith. Ill. Sta. Soil Rpt. 41, 65 p., illus. 1928.
- Morgan County soils. R. S. Smith, E. E. DeTurk, F. C. Bauer, and L. H. Smith. Ill. Sta. Soil Rpt. 42, 64 p., illus. 1929.
- Soil survey of Iowa.—Jefferson County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 50, 64 p., illus. 1927.
- Soil survey of Iowa.—Clarke County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 51, 56 p., illus. 1928.
- Soil survey of Iowa.—Winnebago County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 52, 80 p., illus. 1928.

Soil survey of Iowa.—Appanoose County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 53, 62 p., illus. 1928.

Soil survey of Iowa.—Plymouth County soils. W. H. Stevenson, P. E. Brown, et al. Iowa Sta. Soil Survey Rpt. 54, 62 p., illus. 1929.

The soils of Michigan: Grayling sand. M. M. McCool and A. G. Weidemann. Mich. Sta. Spec. Bul. 180, 24 p., illus. 1929.

Organic matter in Berrien County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 108, 6 p., illus. 1929.

Organic matter in Ingham County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 109, 6 p., illus. 1929.

Organic matter in Kalamazoo County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 110, 6 p., illus. 1929.

Organic matter in Ottawa County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 111, 6 p., illus. 1929.

Organic matter in Van Buren County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 112, 6 p., illus. 1929.

Organic matter in Calhoun County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 113, 6 p., illus. 1929.

Organic matter in Livingston County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 114, 6 p., illus. 1929.

Organic matter in Hillsdale County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 115, 6 p., illus. 1929.

Organic matter in Macomb County soils. M. M. McCool and J. O. Veatch. Mich. Sta. Circ. 116, 6 p., illus. 1929.

Distribution of acid soils, Muskegon County. J. O. Veatch. Mich. Sta. Circ. 117, 6 p., illus. 1929.

Distribution of acid soils, Jackson County. J. O. Veatch. Mich. Sta. Circ. 118, 6 p., illus. 1929.

Distribution of acid soils, Hillsdale County. J. O. Veatch. Mich. Sta. Circ. 119, 6 p., illus. 1929.

Distribution of acid soils, Ingham County. J. O. Veatch. Mich. Sta. Circ. 120, 6 p., illus. 1929.

Distribution of acid soils, Kent County. J. O. Veatch. Mich. Sta. Circ. 121, 6 p., illus. 1929.

Distribution of acid soils, Tuscola County. J. O. Veatch. Mich. Sta. Circ. 122, 6 p., illus. 1929.

Soil survey of the Sun River irrigation project. W. DeYoung. Mont. Sta. Bul. 207, 48 p., illus. 1927.

Soil survey of the Valier irrigation project. W. DeYoung. Mont. Sta. Bul. 217, 40 p., illus. 1928.

The cut-over lands of northern Idaho. J. H. Christ. Idaho Sta. Bul. 158, 35 p., illus. 1928.

The chemical composition of the soils of the Trenton area in New Jersey. A. W. Blair and A. L. Prince. N. J. Stas. Bul. 462, 14 p., illus. 1928.

A southern grass-sedge bog, an ecological study. B. W. Wells and I. V. Shunk. N. C. Sta. Tech. Bul. 32, 75 p., illus. 1928.

Soils of Willamette series and their utilization. W. L. Powers, C. V. Ruzek, and R. E. Stephenson. Oreg. Sta. Bul. 240, 28 p., illus. 1928.

Meaning and use of Willamette soil survey. E. F. Torgerson and W. L. Powers. Oreg. Sta. Circ. 90, 19 p., illus. 1928.

Soil fertility experiments on Volusia and Westmoreland soils. J. W. White and F. D. Gardner. Pa. Sta. Bul. 229, 31 p., illus. 1928.

Concerning Rhode Island soils in different parts of the State. B. L. Hartwell and J. B. Smith. R. I. Sta. Bul. 214, 24 p., illus. 1928.

FERTILIZERS

The influence of various nitrogenous fertilizers on the availability of phosphate and potassium. J. F. Fudge. Ala. Sta. Bul. 227, 49 p., 1928.

The effect of one element of plant food upon the absorption by plants of another element. J. F. Breazeale. Ariz. Sta. Tech. Bul. 19, p. 461-480. 1928.

Fertilizer ratio experiments conducted on Cecil sandy clay loam.—Cotton, corn, and wheat grown in rotation. R. P. Bledsoe and J. J. Skinner. Ga. Sta. Bul. 151, 31 p., illus. 1929.

Fertilizers for Indiana soils and crops. A. T. Wiancko. Ind. Sta. Circ. 162, 8 p., illus. 1928.

Potash from industrial alcohol. L. B. Broughton, H. L. Marshall, and N. C. Thornton. Md. Sta. Bul. 300, p. 37-61. 1928.

Nitrate of soda experiments, 1928. W. B. Rogers. S. C. Sta. Circ. 36, 12 p., illus. 1929.

Experiments with fertilizers on rotated and nonrotated crops. E. B. Reynolds. Tex. Sta. Bul. 390, 39 p., illus. 1928.

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Some relations of green manures to the nitrogen of a soil. T. L. Lyon and B. D. Wilson. N. Y. Cornell Sta. Mem. 115, 29 p., illus. 1928.

Value of lime on Cecil clay loam soil, as measured by the yields and profits of crops grown in rotation under different soil treatments. C. B. Williams, S. K. Jackson, and F. T. Meacham. N. C. Sta. Bul. 261, 26 p., 1928.

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Liming western Oregon soils. R. E. Stephenson and W. L. Powers. Oreg. Sta. Bul. 237, 20 p., illus. 1928.

FIELD CROPS

The Jerusalem artichoke. H. A. Schoth. Oreg. Sta. Circ. 89, 16 p., illus. 1929.

Barley for Michigan farms: Part I, Barley's place in Michigan agriculture. H. C. Rafter. Part II, Barley varieties. E. E. Down, H. M. Brown, and F. H. Clark. Mich. Sta. Spec. Bul. 191, 28 p., illus. 1929.

Barley production and varieties for Wyoming. G. Hartman and A. F. Vass. Wyo. Sta. Bul. 164, p. 95-132, illus. 1929.

Factors affecting the germination and growth of chamiza (*Atriplex canescens*). C. P. Wilson. N. Mex. Sta. Bul. 169, 29 p., illus. 1928.

Red clover seed for Indiana. A. T. Wiancko and R. R. Mulvey. Ind. Sta. Circ. 160, 4 p., illus. 1928.

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- Relation of certain ear and kernel characters of Reid Yellow Dent corn to yield. H. D. Hughes and J. L. Robinson. Iowa Sta. Bul. 257, p. 169-208, illus. 1929.
- The effects of early planting on the composition and yield of corn. B. A. Brown. Conn. Storrs Sta. Bul. 151, p. 37-51, illus. 1928.
- The effect of interplanted legumes on the yields of corn. C. K. McClelland. Ark. Sta. Bul. 229, 19 p. 1928.
- Tillage practices in relation to corn production. T. A. Kiesselbach, A. Anderson, and W. E. Lyness. Nebr. Sta. Bul. 232, 19 p. 1928.
- Corn production in New Mexico. J. C. Overpeck. N. Mex. Sta. Bul. 166, 31 p. 1928.
- Cotton variety test, 1928. R. P. Bledsoe, H. K. Brabham, and G. A. Hale. Ga. Sta. Circ. 83, 3 p. 1929.
- Cotton varieties. J. F. O'Kelly and W. W. Hull. Miss. Sta. Circ. 82, 6 p. 1928.
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- Report of the South Mississippi Branch Experiment Station for 1928. W. R. Perkins, W. S. Anderson, and W. W. Welborne. Miss. Sta. Bul. 266, 38 p. 1928.
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- Thirty-ninth annual report agricultural experiment station of the New Mexico College of Agriculture and Mechanic Arts, 1927-1928. F. Garcia. 68 p., illus. 1928.
- Forty-seventh annual report of the New York State Agricultural Experiment Station for the fiscal year ended June 30, 1928. F. B. Morrison. 64 p. [1928.]
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Thirty-eighth annual report for the fiscal year ended June 30, 1928. E. C. Johnson et al. Wash. Col. Sta. Bul. 229, 71 p. 1928.

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Inspection of feeds. J. E. Smith and J. E. Blaney. R. I. Sta. Ann. Feed Circ., 8 p. 1928.

Inspection of feeds. W. L. Adams and J. E. Blaney. R. I. Sta. Ann. Feed Circ., 12 p. 1929.

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The thirty-second report on food products and the twentieth report on drug products, 1927. E. M. Bailey. Conn. State Sta. Bul. 295, p. 305-355. 1928.

Foods and drugs. J. M. Bartlett. Me. Sta. Off. Insp. 127, 16 p. 1928.

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Commercial agricultural seeds, 1928; insecticides and fungicides, 1928. J. M. Bartlett et al. Me. Sta. Off. Insp. 130, p. 85-116. 1928.

Seed inspection. P. H. Smith et al. Mass. Sta. Control Ser. Bul. 47, 11 p. 1929.

Results of seed tests for 1928, made for the State Department of Agriculture. B. I. Glidden. N. H. Sta. Bul. 235, 17 p. 1928.

Results of seed and legume inoculant inspection for 1928. J. G. Fiske. N. J. Stas. Bul. 484, 104 p. 1929.
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The composition of some commercial insecticides, fungicides, bactericides, rodenticides, and weed killers. A compilation. H. J. Fisher and E. M. Bailey. Conn. State Sta. Bul. 300, p. 205-368. 1929.
 Analyses of materials sold as insecticides and fungicides during 1928. C. S. Cathcart and R. L. Willis. N. J. Stas. Bul. 478, 14 p. 1928.

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Publications available for free distribution. Idaho Sta. Circ. 54, 4 p. 1929.
 Information regarding recent publications. Kans. Sta. Circ. 141, 6 p. 1928.
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 The Utah Agricultural Experiment Station. P. V. Cardon. Utah Sta. Circ. 76, 4 p. 1929.

INCOME, EXPENDITURES, AND OTHER STATISTICS, 1929

By J. I. SCHULTE

The following tables give detailed data regarding (1) personnel, publications, and mailing lists of the experiment stations; (2) revenues and additions to equipment; (3) expenditures from the Hatch, Adams, and Purnell funds; and (4) total disbursements from the United States Treasury under the Hatch, Adams, and Purnell Acts from their passage to the end of the fiscal year, June 30, 1929.

TABLE 3.—*Personnel, publications, and mailing lists of the experiment stations, 1929*

Station	Date of original organization	Date of organization under Hatch Act	Persons on staff	Teachers on staff	Persons on staff who assist in extension work	Publications during fiscal year		Names on mailing list
						Number	Pages	
Alabama.....	Feb. —, 1883	Feb. 24, 1888	40	15	—	4	116	3, 360
Alaska.....	—	—	5	—	—	4	104	3, 525
Arizona.....	—	—, 1889	37	25	—	15	343	3, 000
Arkansas.....	—	—, 1887	42	28	—	16	808	6, 000
California.....	—, 1875	Mar. —, 1888	166	101	124	45	1, 876	4, 000
Colorado.....	—	Feb. 29, 1888	65	32	14	13	351	2, 200
Connecticut (State).....	Oct. 1, 1875	May 18, 1887	39	5	—	18	892	13, 086
Connecticut (Storrs).....	—	do	23	12	2	13	500	10, 500
Delaware.....	—	Feb. 21, 1888	24	7	4	6	224	6, 200
Florida.....	—	—, 1888	60	1	—	22	744	10, 000
Georgia.....	Feb. 18, 1888	July 1, 1889	23	1	—	28	384	7, 500
Guam.....	—	—	5	—	—	1	17	—
Hawaii.....	—	—	8	—	—	1	29	1, 500
Idaho.....	—	Feb. 26, 1892	51	28	6	13	176	21, 500
Illinois.....	—	Mar. 21, 1888	133	81	38	471	3, 282	26, 000
Indiana.....	—, 1885	Jan. —, 1888	105	21	—	55	1, 415	36, 585
Iowa.....	—	Feb. 17, 1888	104	47	—	38	1, 648	19, 405
Kansas.....	—	Feb. 8, 1888	102	75	—	12	549	13, 750
Kentucky.....	Sept. —, 1885	Apr. —, 1888	70	25	5	13	582	12, 800
Louisiana.....	Apr. —, 1886	—	40	6	1	1	23	5, 000
Maine.....	Mar. —, 1885	Oct. 1, 1887	31	2	—	12	304	17, 325
Maryland.....	—, 1888	Apr. —, 1888	45	29	7	71	438	65, 500
Massachusetts.....	—, 1882	Mar. 2, 1888	72	18	—	25	364	15, 000
Michigan.....	—	Feb. 26, 1888	107	65	12	48	1, 730	33, 000
Minnesota.....	Mar. 7, 1885	—, 1888	123	123	78	92	1, 645	36, 000
Mississippi.....	—	Jan. 27, 1888	51	15	—	45	593	18, 000
Missouri.....	—	Jan. —, 1888	83	57	—	65	1, 218	4, 732
Montana.....	—	July 1, 1893	49	17	8	10	524	6, 000
Nebraska.....	Dec. 16, 1884	June 13, 1887	47	17	—	10	355	14, 395
Nevada.....	—	Dec. —, 1887	17	—	—	2	53	5, 000
New Hampshire.....	—, 1886	Aug. 4, 1887	40	18	9	21	345	8, 000
New Jersey (State).....	Mar. 10, 1880	—	182	43	—	452	2, 216	21, 675
New Jersey (College).....	—	Apr. 26, 1888	35	—	—	5	316	10, 000
New Mexico.....	—	Dec. 14, 1889	28	13	5	52	1, 889	76, 255
New York (Cornell).....	—, 1879	Apr. —, 1888	87	79	4	300	1, 056	10, 600
New York (State).....	Mar. —, 1882	—	56	—	—	36	1, 889	76, 255
North Carolina.....	Mar. 12, 1877	Mar. 7, 1887	48	11	1	18	764	8, 670
North Dakota.....	—	Mar. —, 1890	61	19	1	13	462	8, 300
Ohio.....	Apr. 25, 1882	Apr. 2, 1888	118	25	2	96	1, 356	70, 000
Oklahoma.....	—	Oct. 27, 1890	43	34	—	6	125	3, 433
Oregon.....	—	July —, 1888	68	30	—	31	828	1, 750
Pennsylvania.....	—	June 30, 1887	108	79	—	27	770	31, 000
Porto Rico.....	—	—	8	—	—	1	31	3, 000
Rhode Island.....	—	July 30, 1888	22	2	—	13	257	5, 000
South Carolina.....	—	Jan. —, 1888	42	6	6	13	508	7, 000
South Dakota.....	—	Mar. 13, 1887	31	22	3	9	268	5, 000
Tennessee.....	June 8, 1887	Aug. 4, 1887	32	2	—	16	118	13, 680
Texas.....	—	Apr. 3, 1889	89	—	—	30	997	67, 182
Utah.....	—	—, 1890	37	26	5	12	344	10, 000
Vermont.....	Nov. 24, 1886	Feb. 28, 1888	22	10	1	15	500	4, 200
Virginia.....	—, 1888	—, 1891	39	11	2	8	661	12, 000
Virgin Islands.....	—	—	4	1	1	—	—	600
Washington.....	—	—, 1891	52	24	—	13	553	16, 247
West Virginia.....	—	June 11, 1888	50	28	7	58	362	28, 114
Wisconsin.....	—, 1883	—, 1887	116	87	67	22	759	59, 310
Wyoming.....	—	Mar. 1, 1891	37	15	1	9	216	8, 000
Total.....	—	—	3, 096	1, 438	441	2, 440	36, 988	909, 879

¹ Including 26 also on college station staff, not included in total.

TABLE 4.—*Revenues and expenditures*

Station	Revenues						
	Federal			State	Balances from previous year ¹	Fees	Sales
	Hatch fund	Adams fund	Purnell fund				
Alabama.....	\$15,000	\$15,000	\$50,000	\$155,724.20	\$43,320.22	-----	\$20,541.01
Alaska ²	-----	-----	-----	-----	-----	-----	-----
Arizona.....	15,000	15,000	50,000	103,638.02	1,785.43	-----	6,447.97
Arkansas.....	15,000	15,000	50,000	176,677.44	-----	-----	28,649.18
California.....	15,000	15,000	50,000	679,551.30	9,184.94	\$12,155.43	100,610.59
Colorado.....	15,000	15,000	50,000	124,065.76	18,190.28	-----	44,992.46
Connecticut (State).....	7,500	7,500	25,000	187,065.71	-----	20,300.00	-----
Connecticut (Storrs).....	7,500	7,500	25,000	37,000.00	3,070.19	-----	-----
Delaware.....	15,000	15,000	50,000	18,500.00	1,783.29	-----	18,622.15
Florida.....	15,000	15,000	50,000	313,055.09	22,433.52	-----	20,357.47
Georgia.....	15,000	15,000	50,000	50,000.00	5,198.03	-----	11,755.07
Guam ²	-----	-----	-----	-----	-----	-----	-----
Hawaii ²	-----	-----	-----	-----	-----	-----	-----
Idaho.....	15,000	15,000	50,000	44,909.19	827.00	-----	3,086.90
Illinois.....	15,000	15,000	50,000	391,226.25	34,224.57	-----	105,718.58
Indiana.....	15,000	15,000	50,000	339,223.21	109,838.64	153,198.49	92,247.78
Iowa.....	15,000	15,000	50,000	235,000.00	6,673.13	-----	46,025.96
Kansas.....	15,000	15,000	50,000	104,240.00	12,835.26	72,144.75	16,159.16
Kentucky.....	15,000	15,000	50,000	139,500.00	31,899.82	123,425.83	60,499.23
Louisiana.....	15,000	15,000	50,000	97,233.37	3,413.11	34,160.92	14,221.23
Maine.....	15,000	15,000	50,000	35,000.00	8,500.63	11,342.07	14,243.88
Maryland.....	15,000	15,000	50,000	73,387.30	2,151.58	-----	30,329.12
Massachusetts.....	15,000	15,000	50,000	157,887.24	-----	70,593.88	19,303.34
Michigan.....	15,000	15,000	50,000	301,669.27	-----	-----	31,146.24
Minnesota.....	15,000	15,000	50,000	285,573.93	-----	-----	110,177.04
Mississippi.....	15,000	15,000	50,000	214,121.49	11,819.19	-----	32,610.92
Missouri.....	15,000	15,000	50,000	42,249.27	34,582.42	36,877.58	66,947.35
Montana.....	15,000	15,000	50,000	116,343.24	5,305.88	-----	34,882.54
Nebraska.....	15,000	15,000	50,000	158,422.27	-----	-----	65,490.00
Nevada.....	15,000	15,000	50,000	4,351.49	735.90	-----	4,979.22
New Hampshire.....	15,000	15,000	50,000	5,500.00	2,459.37	-----	2,570.32
New Jersey (State).....	-----	-----	-----	325,212.36	-----	49,361.27	44,940.43
New Jersey (College).....	15,000	15,000	50,000	-----	-----	-----	-----
New Mexico.....	15,000	15,000	50,000	7,500.00	14,171.95	-----	13,457.16
New York (State).....	1,500	1,500	5,000	318,710.00	6,285.19	-----	16,873.72
New York (Cornell).....	13,500	13,500	45,000	305,106.28	-----	-----	39,874.28
North Carolina.....	15,000	15,000	50,000	124,954.97	3,376.71	-----	66,306.50
North Dakota.....	15,000	15,000	50,000	1,000.00	163,905.39	-----	86,446.16
Ohio.....	15,000	15,000	50,000	916,062.67	464,772.87	-----	86,094.21
Oklahoma.....	15,000	15,000	50,000	40,000.00	7,724.74	-----	15,630.11
Oregon.....	15,000	15,000	50,000	193,000.00	52,959.47	4,700.43	80,485.35
Pennsylvania.....	15,000	15,000	50,000	120,429.19	-----	-----	31,102.26
Porto Rico ²	-----	-----	-----	-----	-----	-----	-----
Rhode Island.....	15,000	15,000	50,000	-----	4,487.60	5,538.00	6,143.68
South Carolina.....	15,000	15,000	50,000	84,483.48	-----	-----	72,620.58
South Dakota.....	15,000	15,000	50,000	29,791.75	11,814.93	-----	14,905.53
Tennessee.....	15,000	15,000	50,000	40,757.52	-----	-----	24,570.70
Texas.....	15,000	15,000	50,000	334,714.70	52,033.85	-----	131,951.90
Utah.....	15,000	15,000	50,000	53,186.60	-----	-----	25,811.40
Vermont.....	15,000	15,000	50,000	-----	57.71	19,756.23	1,274.60
Virginia.....	15,000	15,000	50,000	82,225.00	2,608.03	-----	15,385.56
Virgin Islands ²	-----	-----	-----	-----	-----	-----	-----
Washington.....	15,000	15,000	50,000	117,979.03	16,309.58	-----	56,174.40
West Virginia.....	15,000	15,000	50,000	93,500.00	2,167.65	-----	54,273.12
Wisconsin.....	15,000	15,000	50,000	288,047.45	-----	-----	83,395.34
Wyoming.....	15,000	15,000	50,000	53,025.07	-----	-----	29,138.70
Total.....	720,000	720,000	2,400,000	8,120,801.08	1,172,908.07	613,554.88	1,996,470.40

¹ Not including balances from Federal funds.² Supported by direct appropriations to the U. S. Department of Agriculture.

for additions to equipment, 1929

Revenues—Continued		Additions to equipment						
Miscellaneous	Total	Buildings	Library	Apparatus	Farm implements	Livestock	Miscellaneous	Total
\$16,196.32	\$315,781.75	\$48,115.14	\$1,324.55	\$7,403.87	\$16,849.69	\$1,119.50	\$5,876.96	\$80,689.71
85,000.00	85,000.00	13,935.30	36.45	426.82	987.58	471.25	1,402.04	17,259.44
-----	191,871.42	2,425.55	-----	-----	3,960.04	-----	-----	6,385.59
35,633.29	285,326.62	98,962.20	2,549.45	7,490.68	1,983.17	765.03	1,591.69	113,342.22
2,777.11	917,135.55	90,378.58	10,000.00	-----	-----	-----	37,180.03	137,558.61
7,071.76	270,025.61	5,868.00	1,193.00	4,595.00	4,792.00	800.00	12,000.00	29,548.00
17,202.74	254,437.50	3,862.79	1,162.13	1,817.17	122.40	5,971.16	1,511.39	14,447.04
-----	97,272.93	2,805.53	1,051.00	621.58	166.77	3,327.56	1,235.98	9,208.42
-----	118,905.44	3,476.47	928.49	1,649.35	1,905.10	285.00	1,754.40	9,998.81
-----	435,845.99	18,888.57	3,163.11	11,700.40	3,554.61	893.25	8,371.23	46,571.17
-----	146,953.10	-----	1,300.00	3,000.00	1,500.00	-----	-----	5,800.00
25,000.00	25,000.00	-----	-----	-----	-----	-----	-----	-----
54,940.00	54,940.00	-----	-----	-----	-----	-----	-----	-----
-----	128,823.09	5,000.00	200.00	1,500.00	1,000.00	3,000.00	500.00	11,200.00
61,840.70	611,169.40	-----	-----	-----	-----	-----	-----	-----
-----	836,348.85	102,993.83	2,254.82	5,660.92	13,668.36	1,316.60	4,425.82	130,320.35
-----	367,699.09	3,550.00	4,736.45	4,736.45	-----	14,212.90	-----	26,577.69
-----	285,379.17	9,476.69	39.65	1,981.44	10,807.91	11,556.67	797.83	34,660.19
5,890.00	441,214.88	-----	658.77	1,201.41	414.37	2,933.00	1,837.65	7,045.20
1,544.41	230,573.04	5,084.98	131.35	2,685.93	4,610.34	3,449.66	8,970.48	24,932.74
-----	149,086.58	2,466.83	1,034.30	2,332.84	737.50	250.00	511.00	7,332.47
35,686.38	221,554.38	2,295.13	640.07	828.89	3,696.01	873.09	9,999.64	18,332.83
-----	327,784.46	1,974.94	594.41	2,945.65	3,148.21	85.50	-----	8,748.71
598.76	413,414.27	2,679.00	1,436.75	3,905.50	389.50	4,629.50	3,920.35	16,960.60
18,747.61	494,498.58	33,600.91	1,590.57	5,256.72	11,750.65	7,778.06	-----	59,976.91
6,900.00	345,451.60	182,630.00	6,407.29	15,350.23	26,026.21	36,086.66	190,739.05	457,239.44
13,452.45	274,109.07	-----	1,113.95	11,111.86	7,491.01	1,565.73	3,776.95	25,059.50
46.48	236,578.14	1,600.00	1,150.00	1,535.00	6,245.09	1,120.00	1,255.00	12,905.00
-----	303,912.27	7,160.47	483.35	6,293.54	7,403.11	11,536.62	8,108.08	40,985.17
-----	90,066.61	1,026.75	85.00	228.58	150.00	755.00	300.00	2,545.33
29,435.54	119,965.23	1,172.09	716.92	2,020.91	2,603.12	492.21	2,067.23	9,072.48
150.00	419,664.06	-----	2,108.24	13,528.64	3,078.38	91.00	8,140.80	26,947.06
-----	80,000.00	-----	-----	-----	-----	-----	-----	-----
-----	115,129.11	2,339.72	288.69	1,366.45	2,897.48	1,437.80	1,160.50	9,490.64
-----	349,868.91	480.00	2,326.41	3,810.77	10,048.26	1,100.00	883.94	18,649.38
7,228.41	421,208.97	3,821.17	2,770.21	5,519.78	5,255.10	204.33	2,905.67	20,476.26
4,025.00	278,663.18	25,195.42	758.86	1,434.82	4,617.13	7,735.53	3,361.24	43,103.00
8,000.00	339,351.55	-----	836.42	2,353.54	3,981.25	7,015.15	-----	14,186.36
5,603.01	1,552,532.76	35,923.64	417.27	4,310.98	31,894.68	21,334.92	48,663.33	142,544.82
-----	143,354.85	241.88	375.66	2,254.45	148.81	4,082.72	2,279.55	9,383.07
6,552.30	417,697.55	4,394.06	41.47	2,615.48	10,149.49	967.40	-----	18,167.90
2,590.66	234,122.11	116,800.00	54.26	6,250.20	1,311.80	100.00	5,022.92	129,539.18
56,460.00	56,460.00	-----	-----	-----	-----	-----	-----	-----
-----	96,169.28	7,304.00	448.00	452.00	1,418.00	377.00	2,158.00	12,157.00
-----	237,104.06	12,000.00	760.00	3,200.00	2,840.00	700.00	-----	19,500.00
5,234.70	141,746.91	360.00	100.00	2,000.00	650.00	-----	-----	3,110.00
-----	145,328.22	15,913.67	381.20	1,296.88	3,118.28	2,942.00	1,250.53	24,902.56
70,360.58	669,061.03	11,061.80	3,897.16	9,020.10	1,719.05	6,329.32	50,146.70	82,174.13
-----	158,998.00	2,891.66	521.15	1,339.00	1,251.71	280.00	821.25	7,104.77
-----	101,088.54	5,107.22	196.85	1,525.09	191.75	1.50	-----	7,022.41
-----	180,218.59	3,000.00	800.00	2,700.00	1,500.00	300.00	500.00	8,800.00
25,000.00	25,000.00	-----	40.74	38.39	14.00	43.27	99.59	235.99
-----	270,463.01	2,163.22	2,388.27	275.18	1,783.53	262.50	1,310.68	8,183.38
-----	229,940.77	9,689.19	798.61	2,907.67	5,929.25	5,736.00	21,409.74	46,471.06
55,149.57	506,592.36	-----	1,505.75	16,750.40	4,315.60	2,640.92	3,562.39	28,775.06
-----	162,163.77	6,305.00	800.00	3,400.77	2,168.50	5,527.29	53.03	18,254.59
664,317.78	16,408,052.21	916,421.40	67,938.94	196,931.33	236,244.71	184,483.20	461,862.66	2,063,882.24

TABLE F.—*Expenditure from United States appropriations received under*

Station	Classified expenditures							
	Amount of ap- propri- ation	Salaries	Labor	Publica- tions	Postage and station- ery	Freight and express	Heat, light, water, and power	Chem- ical supplies
Alabama.....	\$15,000	\$10,023.64	\$1,337.92	\$568.08	\$705.74	\$77.89		\$8.49
Arizona.....	15,000	14,999.76			.24			
Arkansas.....	15,000	6,517.88	2,985.06	1,979.95	156.61	145.89	\$60.64	363.41
California.....	15,000	15,000.00						
Colorado.....	15,000	14,567.80		432.20				
Connecticut (State).....	7,500	7,500.00						
Connecticut (Storrs).....	7,500	7,500.00						
Delaware.....	15,000	8,850.20	1,155.44	1,404.44	962.68	30.13	323.76	198.10
Florida.....	15,000	15,000.00						
Georgia.....	15,000	7,365.00	1,354.17	1,873.19	705.62	140.34	391.94	5.94
Idaho.....	15,000	10,337.25	3,220.37	359.16	151.71			202.72
Illinois.....	15,000	15,000.00						
Indiana.....	15,000	14,308.28	496.81		1.05			
Iowa.....	15,000	8,415.00	250.50	1,090.59	53.06			141.78
Kansas.....	15,000	9,700.00	4,685.16		119.49		1.80	13.93
Kentucky.....	15,000	14,920.85						
Louisiana.....	15,000	6,471.65	5,520.44		221.86	7.55	170.66	
Maine.....	15,000	8,628.00	2,134.40		128.58	51.23	779.98	62.83
Maryland.....	15,000	14,410.77		463.50	43.84			68.25
Massachusetts.....	15,000	14,631.83			.15			
Michigan.....	15,000	15,000.00						
Minnesota.....	15,000	15,000.00						
Mississippi.....	15,000	10,591.96	1,998.82		217.07	103.13	246.00	
Missouri.....	15,000	7,618.63	2,055.86	22.50	587.06	219.24	5.78	112.55
Montana.....	15,000	8,250.00	3,036.13	899.44	96.15	6.21		83.29
Nebraska.....	15,000	15,000.00						
Nevada.....	15,000	9,773.50	3,068.70		562.74	10.82	206.20	38.70
New Hampshire.....	15,000	9,927.36	920.02	995.63	717.27	307.94	700.00	158.43
New Jersey.....	15,000	11,240.00	1,088.40		302.50	1.41	266.22	179.19
New Mexico.....	15,000	8,376.46	2,584.80	1,592.57	101.71	145.15	278.18	176.22
New York (Cornell).....	13,500	7,987.63	2,888.31		40.86	43.04	.85	439.42
New York (State).....	1,500	1,230.86	269.14					
North Carolina.....	15,000	13,313.00	345.39		36.87	27.16		16.15
North Dakota.....	15,000	15,000.00						
Ohio.....	15,000	6,460.00	88.56		675.85	294.40	177.42	227.46
Oklahoma.....	15,000	6,345.31	1,421.23	761.67	191.15	11.03	63.85	530.66
Oregon.....	15,000	9,192.34	2,710.96	22.39	120.69	69.49	85.15	307.30
Pennsylvania.....	15,000	12,331.67	995.83	1,457.63		6.89		
Rhode Island.....	15,000	6,876.45	3,508.63	896.13	396.10	166.34	143.83	46.03
South Carolina.....	15,000	9,360.00	1,481.09	514.62	695.01	89.31	55.07	158.13
South Dakota.....	15,000	7,824.94	3,902.47	774.40	91.87	15.05	10.25	100.95
Tennessee.....	15,000	9,595.75	1,901.69	945.75	387.91	43.03	1,207.15	32.87
Texas.....	15,000	13,855.00	449.72		59.99	47.55		141.99
Utah.....	15,000	11,016.82	1,053.69		21.90	29.03	42.00	72.24
Vermont.....	15,000	9,102.95	918.63	1,702.27	412.59	16.70	1,092.74	171.09
Virginia.....	15,000	9,283.32	3,213.35	672.43	530.15	37.92	58.70	153.13
Washington.....	15,000	10,510.41	1,809.84	1,361.82	90.10			197.17
West Virginia.....	15,000	7,484.11	3,540.27	97.39			62.36	775.67
Wisconsin.....	15,000	11,760.00	1,000.00	154.36	.40			760.68
Wyoming.....	15,000	9,330.00	5,670.00					
Total.....	720,000	522,786.38	75,061.80	21,042.11	9,586.57	2,143.87	6,430.53	5,944.77

the act of March 2, 1887 (Hatch Act), for the year ended June 30, 1929

Classified expenditures—Continued

Seeds, plants, and sundry supplies	Ferti- lizers	Feeding stuffs	Library	Tools, imple- ments, and ma- chinery	Furni- ture and fixtures	Scientific apparatus	Live- stock	Travel- ing ex- penses	Con- tingent ex- penses	Build- ings and land
\$41.85		\$555.00	\$402.20	\$855.47		\$423.72				
587.90	\$53.00	1, 110.86	74.00	40.60	\$159.21	483.54	\$28.01	\$233.36		\$20.08
194.29	209.13		618.74	168.21	391.90			212.38	\$1.00	279.60
767.27	109.80	4.40	902.23	616.77	126.30	57.09		412.88		167.06
103.42		36.35		114.25				470.57	4.20	
		193.86								
1, 448.97		3, 520.19				65.24		14.67		
73.97		1.55		139.50		13.88		250.72		
								79.15		
154.60	236.43			212.67	367.10		875.00	150.00	225.50	386.54
164.54		2, 230.22	337.63	10.35	178.84	67.24		187.73		38.43
13.64								368.02		
392.82	363.00	299.80	5.00	253.22			.75	391.78	136.65	
321.17		1, 122.71	551.02	205.27	114.42	691.39	14.40	5.29	5.60	1, 347.11
59.03		389.82	485.50	279.42	295.00	310.12	63.00	746.89		
262.17		108.40	19.26	325.28	143.48		125.00	281.94	40.30	33.51
135.61	84.53		405.59	2.24	128.63	55.57		461.18		
149.01		360.00	35.47	44.24	218.49	149.56		824.08	23.65	117.78
360.03	305.44	165.30	150.76	196.64	100.00	21.12	62.50	275.92		107.20
102.06	326.79		25.74	945.11	100.13	347.94		252.12		
81.82				93.31		172.49		913.81		
202.13	75.00	4, 252.77		1, 313.81	143.42	194.92		355.31		538.95
2, 985.11	48.85	1, 109.58	38.70	183.32	96.32	356.24		840.78		16.20
617.11	48.31		9.50	143.55		525.10		1, 148.11		
110.75	95.49			1.74						
596.27	509.32	243.95	172.45	457.00	148.75	57.88	62.50	419.66		298.71
397.61	313.60	361.35	674.61	509.09	182.64			201.76		6.11
376.64	6.00	693.68		183.13	7.95	233.36	259.60	133.13		386.58
96.71	3.00		448.51	73.07	33.06	39.95		177.61	2.56	11.38
					39.76	405.99				
324.20		1, 224.02	24.70	86.67		22.14		1, 082.59		
177.09	72.50		127.30	267.41	185.91			241.23		427.21
297.24	31.00	1.10	128.37	145.19	68.58	70.21		253.91	84.38	50.40
93.62				456.63	99.60			380.81	5.00	
437.97	241.90		7.50	1, 572.65		167.80		612.38		
24.04				254.15	595.60	330.92		119.85		
12, 150.66	3, 133.09	17, 984.91	5, 644.78	10, 149.96	3, 925.09	5, 263.41	1, 490.76	12, 499.62	528.84	4, 232.85

TABLE 5.—Expenditures from United States appropriations received under

Station	Amount of appropriation	Classified expenditures						
		Salaries	Labor	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies	Seeds, plants, and sundry supplies
Alabama.....	\$15,000	\$11,047.01	\$717.40	\$24.55	\$94.44	\$100.00	\$1,033.41	\$62.56
Arizona.....	15,000	8,967.49	2,061.93	11.02	72.85	38.00	249.82	251.45
Arkansas.....	15,000	9,531.68	1,862.75	22.15	107.30	111.59	951.85	443.33
California.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----
Colorado.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----
Connecticut (State).....	7,500	7,500.00	-----	-----	-----	-----	-----	-----
Connecticut (Storrs).....	7,500	7,500.00	-----	-----	-----	-----	-----	-----
Delaware.....	15,000	10,973.53	1,009.72	11.68	21.71	-----	1,161.69	756.67
Florida.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----
Georgia.....	15,000	9,890.02	938.49	5.05	191.56	485.23	425.02	42.62
Idaho.....	15,000	11,143.50	1,643.67	23.60	-----	3.65	803.60	179.12
Illinois.....	15,000	11,119.93	3,880.02	-----	-----	-----	-----	-----
Indiana.....	15,000	11,511.64	153.40	6.47	56.46	-----	707.16	68.38
Iowa.....	15,000	8,975.00	2,997.74	7.90	3.04	-----	1,100.41	673.72
Kansas.....	15,000	10,300.00	3,645.37	27.95	-----	-----	201.65	20.30
Kentucky.....	15,000	14,611.30	164.57	2.50	4.94	-----	21.01	-----
Louisiana.....	15,000	10,833.33	1,305.47	30.88	58.26	-----	431.37	67.14
Maine.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----
Maryland.....	15,000	13,986.65	-----	24.10	-----	-----	527.37	41.50
Massachusetts.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----
Michigan.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----
Minnesota.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----
Mississippi.....	15,000	10,257.42	3,099.05	96.38	31.97	256.10	34.31	237.37
Missouri.....	15,000	4,714.36	4,080.52	145.55	192.91	113.37	856.61	659.46
Montana.....	15,000	11,202.04	1,544.53	29.39	14.56	.25	510.27	167.29
Nebraska.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----
Nevada.....	15,000	9,413.84	2,401.74	23.49	78.42	-----	250.56	103.65
New Hampshire.....	15,000	12,344.60	930.31	7.72	35.50	-----	320.54	107.09
New Jersey.....	15,000	12,110.00	297.57	24.81	16.95	108.32	840.34	86.42
New Mexico.....	15,000	10,688.31	2,813.10	31.28	125.51	299.79	403.04	261.99
New York (Cornell).....	13,500	12,590.00	659.44	.09	-----	-----	250.47	-----
New York (State).....	1,500	1,500.00	-----	-----	-----	-----	-----	-----
North Carolina.....	15,000	11,970.00	469.40	28.19	60.82	72.03	681.97	174.21
North Dakota.....	15,000	15,000.00	-----	-----	-----	-----	-----	-----
Ohio.....	15,000	9,370.81	4,748.72	-----	-----	-----	150.39	55.90
Oklahoma.....	15,000	6,238.34	3,573.10	-----	6.46	8.00	1,461.22	227.45
Oregon.....	15,000	12,309.00	1,291.87	21.43	42.72	200.79	684.23	277.63
Pennsylvania.....	15,000	13,742.46	980.38	2.35	-----	-----	66.93	11.38
Rhode Island.....	15,000	10,488.29	2,772.29	14.50	47.86	162.36	184.29	182.99
South Carolina.....	15,000	8,856.64	2,358.98	220.51	35.71	206.43	222.05	243.48
South Dakota.....	15,000	7,708.24	4,187.00	32.76	41.65	-----	339.94	103.59
Tennessee.....	15,000	13,356.00	427.17	2.55	51.08	157.58	67.89	75.72
Texas.....	15,000	13,222.50	957.23	4.02	110.07	-----	389.71	198.18
Utah.....	15,000	10,500.08	2,605.12	49.45	61.87	-----	556.42	227.33
Vermont.....	15,000	11,356.18	1,332.19	23.28	32.10	140.89	329.14	246.16
Virginia.....	15,000	12,024.95	1,340.39	14.51	-----	-----	210.47	40.01
Washington.....	15,000	11,710.93	2,089.36	6.99	-----	-----	504.69	29.38
West Virginia.....	15,000	11,386.54	820.24	2.00	8.25	26.46	541.17	454.91
Wisconsin.....	15,000	11,350.00	3,378.92	-----	-----	-----	69.02	13.50
Wyoming.....	15,000	14,441.80	558.20	-----	-----	-----	-----	-----
Total.....	720,000	567,143.86	70,097.35	979.10	1,604.97	2,496.89	17,541.03	6,791.88

the act of March 16, 1906 (Adams Act), for the year ended June 30, 1929

Classified expenditures—Continued

Fertiliz- ers	Feeding stuffs	Library	Tools, imple- ments, and ma- chinery	Furni- ture and fixtures	Scientific apparatus	Live- stock	Travel- ing ex- penses	Contin- gent ex- penses	Build- ings and land
\$18.95		\$3.82	\$721.93	\$40.40	\$1,150.98		\$3.50		
27.50	\$321.67	8.77	1,139.31	307.25	101.50		1,262.66	\$359.00	\$150.00
		166.73	9.66	111.29	929.44	\$3.00	395.57		4.49
		26.50	24.50		908.59		105.41		
	1,200.29	7.14	66.47	17.50	1,431.70		253.33		44.53
	54.99		.50	22.85	601.94	23.00	495.88	3.70	
46.09	839.50			705.02	864.38	31.50	10.00		
	837.09		16.20		373.06		15.84		
	586.17		10.26		185.30	15.00			8.00
	7.00	6.44				175.00	7.24		
	254.77	53.65	1,612.24	152.55	80.09	112.00	8.25		
		5.25	5.87	1.15	383.93		24.18		
91.78	98.60	12.32	648.76				75.50		60.44
	1,855.83	5.00	428.92	28.40	581.86	495.11	178.96	11.00	646.14
		50.04	56.75	63.87	352.37	26.00	982.64		
	682.43	1.50		516.75	351.78	788.84	387.00		
146.65	369.37		31.33	53.32	295.61		65.64		292.92
		7.50	10.05	73.03	621.75		347.19	26.42	429.65
164.50	21.00	67.53	217.66		47.92	310.75	63.02		84.60
2.60	3.50		306.92		512.83		717.53		
	31.49	8.00	382.68	2.25	182.76				67.00
	856.23		158.21		1,630.99	400.00	90.00		350.00
60.15	8.86		25.40	54.40	6.75		16.77		
					196.50				
87.80	621.60	31.35	54.30		129.49	109.00	18.84		95.04
3.18		9.50	276.35		2,278.53		260.64		28.00
	87.15	62.42	144.04	492.50	351.07		749.54		700.00
		60.65	1.45	60.10	319.01		292.49		128.31
	68.29	3.00		10.00	37.00				
		6.70	164.37	3.93	470.37		354.36		
34.06	6.74	26.80	47.68	305.84	1,038.59	1.50	78.00	.85	
2.00	441.40		284.21	14.92	600.56		22.60		3.98
			423.24	2.00	48.28		185.13		
105.50	200.85	14.52	409.50		710.58		286.73		32.75
	160.20		7.13	15.75	5.48				
790.76	9,615.02	645.13	7,685.89	3,055.07	17,780.99	2,490.70	7,754.44	400.97	3,125.95

TABLE 7.—Expenditures from United States appropriations received under the

Station	Amount of appropriation	Classified expenditures						
		Salaries	Labor	Publications	Postage and stationery	Freight and express	Heat, light, water, and power	Chemical supplies
Alabama.....	\$50,000	\$27,718.92	\$6,612.56	-----	\$410.02	\$193.44	\$233.02	\$2,361.13
Arizona.....	50,000	30,210.89	3,422.26	\$1,146.20	35.60	342.78	584.50	1,510.52
Arkansas.....	50,000	33,044.51	1,950.73	6,165.58	927.61	98.95	104.71	675.64
California.....	50,000	47,681.15	2,318.85	-----	-----	-----	-----	-----
Colorado.....	50,000	40,711.85	1,352.50	303.20	325.82	2.41	168.00	552.70
Connecticut (State).....	25,000	17,766.67	752.47	-----	87.11	42.29	-----	1,441.36
Connecticut (Storrs).....	25,000	13,263.79	6,589.73	-----	307.82	12.93	-----	-----
Delaware.....	50,000	34,624.70	2,435.40	1,529.20	154.94	176.16	569.79	679.09
Florida.....	50,000	31,016.28	4,225.00	1,063.88	1,004.98	-----	32.88	2,474.91
Georgia.....	50,000	27,996.75	7,599.73	749.45	495.72	506.49	1,171.01	870.43
Idaho.....	50,000	36,638.82	3,013.07	817.07	142.63	89.89	7.60	1,207.64
Illinois.....	50,000	28,527.21	5,493.86	4,248.24	511.91	199.89	-----	206.12
Indiana.....	50,000	34,127.51	6,254.47	173.64	461.74	46.13	1.88	84.34
Iowa.....	50,000	28,350.73	6,833.30	1,630.18	577.25	51.30	391.99	929.58
Kansas.....	50,000	27,500.20	15,833.80	8.92	145.43	.57	104.13	829.89
Kentucky.....	50,000	39,856.10	2,380.38	1,817.68	147.87	36.41	-----	467.52
Louisiana.....	50,000	31,384.96	5,875.90	-----	246.15	465.68	393.61	312.29
Maine.....	50,000	38,962.54	120.04	7.50	552.11	119.28	125.70	193.23
Maryland.....	50,000	38,056.93	3,819.73	2,611.81	117.46	24.06	74.30	756.51
Massachusetts.....	50,000	41,769.19	1,446.86	643.21	424.42	5.52	-----	262.36
Michigan.....	50,000	39,707.29	4,995.43	118.50	537.54	9.74	-----	470.65
Minnesota.....	50,000	40,376.12	300.00	1,683.66	53.45	34.21	-----	552.64
Mississippi.....	50,000	29,313.36	7,769.54	1,405.33	387.43	338.51	248.84	520.74
Missouri.....	50,000	22,203.25	8,930.50	355.97	407.23	253.41	70.74	868.91
Montana.....	50,000	30,037.00	9,684.25	720.79	411.27	166.01	-----	839.63
Nebraska.....	50,000	31,418.33	4,169.77	1,498.03	138.48	272.38	124.05	345.18
Nevada.....	50,000	26,981.85	9,230.22	-----	1,662.95	292.50	154.38	1,066.81
New Hampshire.....	50,000	36,403.76	2,516.51	412.70	127.97	187.48	-----	815.80
New Jersey.....	50,000	37,047.50	3,728.43	14.69	82.64	11.65	643.99	1,846.68
New Mexico.....	50,000	22,969.40	6,338.69	600.04	393.63	649.66	229.65	188.36
New York (Cornell).....	45,000	37,181.86	1,476.23	30.34	392.52	21.01	-----	749.91
New York (State).....	5,000	3,000.00	1,058.06	-----	-----	-----	-----	-----
North Carolina.....	50,000	31,691.99	2,616.69	1,882.96	213.27	169.92	38.39	563.72
North Dakota.....	50,000	42,342.38	1,141.95	1,444.27	23.37	-----	47.97	235.88
Ohio.....	50,000	29,844.17	11,655.44	351.39	200.00	-----	-----	911.24
Oklahoma.....	50,000	28,618.99	6,787.84	1,136.45	550.40	13.68	63.18	825.10
Oregon.....	50,000	28,443.61	6,627.34	4,020.24	387.56	439.16	282.27	949.98
Pennsylvania.....	50,000	31,894.16	4,301.20	1,935.74	71.78	217.27	194.79	501.03
Rhode Island.....	50,000	32,616.86	6,428.16	599.89	276.14	216.61	846.37	163.10
South Carolina.....	50,000	27,107.69	9,006.51	2,158.77	688.69	357.48	279.99	689.70
South Dakota.....	50,000	26,864.69	8,240.55	1,594.81	748.68	96.42	26.10	1,069.20
Tennessee.....	50,000	40,147.83	420.42	16.13	163.47	194.88	107.68	712.77
Texas.....	50,000	28,276.67	9,551.53	-----	643.07	381.48	-----	808.38
Utah.....	50,000	28,863.17	9,317.53	475.95	386.58	202.00	174.36	376.43
Vermont.....	50,000	25,036.91	8,593.59	1,596.91	930.40	49.73	1,580.14	605.23
Virginia.....	50,000	30,726.66	6,792.94	3,364.92	405.29	-----	-----	451.16
Washington.....	50,000	34,014.79	8,297.72	357.64	283.94	93.83	13.60	1,106.48
West Virginia.....	50,000	33,027.33	6,109.41	540.28	79.83	-----	112.36	602.55
Wisconsin.....	50,000	26,152.72	16,612.35	-----	20.95	2.64	2.00	1,230.90
Wyoming.....	50,000	34,807.88	5,356.19	228.35	25.88	198.34	.40	179.08
Total.....	2,400,000	1,566,447.92	276,385.63	51,454.51	17,771.00	7,284.18	9,204.37	36,062.50

act of February 24, 1925 (Purnell Act), for the year ended June 30, 1929

Classified expenditures—Continued

Seeds, plants, and sundry supplies	Ferti- lizers	Feeding stuffs	Library	Tools, imple- ments, and ma- chinery	Furni- ture and fixtures	Scien- tific appa- ratus	Live- stock	Travel- ing ex- penses	Con- tin- gent ex- penses	Build- ings and land
\$494.83	\$47.00	\$1,049.67	\$273.96	\$299.98	\$1,839.34	\$5,674.85		\$2,791.28		
730.34	279.00	174.59	9.00	1,791.55	69.50	3,432.63		4,433.97	\$84.60	\$1,742.07
204.25		367.95	566.81	642.67	1,289.59	1,511.86		2,388.11		41.03
141.71		194.36	202.44	9.25	872.96	1,071.95	\$48.00	3,463.39	360.00	219.46
64.80	2.70		7.65	268.20	23.84	550.44		3,936.32	76.64	2,979.51
334.59			22.36		702.49			3,766.29		
956.10	170.86	1,974.55	193.05	207.04	741.75	740.76		2,968.12	134.90	1,743.59
380.93	402.08	74.21		690.08	1,906.08	4,378.03	12.52	2,216.69	18.00	103.45
931.16	270.67	3,053.23	135.47	1,321.94	89.13	1,520.02	417.17	2,154.52	50.25	666.86
389.49		455.55	37.57	196.39	424.35	781.54	27.00	5,522.46	6.90	242.03
91.68		701.36	11.64	1,861.95	3,399.58	280.63	14.40	4,395.49	14.83	41.21
372.95		103.08	1.00	55.42	1,288.36	706.14		6,321.74	1.60	
1,544.50	75.25	3,477.83	19.93	311.41	1,136.37	1,482.51	505.35	2,665.65		16.87
899.55		345.99		536.23	130.44	814.22	2,270.00	408.44		172.19
47.51		521.63	210.07	71.19	1,540.24	239.30		2,664.10		
795.22	74.56	867.48		2,705.25	1,017.10	1,862.39	1,583.76	842.31		1,573.34
323.14	585.56	762.77	26.52	1,020.96	735.00	1,652.38		3,739.50	309.04	764.73
271.45	233.71		19.97	156.74	710.30	79.50	873.09	2,167.94		26.50
254.48		141.95	43.66	82.23	108.69	402.57	85.50	4,326.27		3.09
152.89		270.56	17.04	139.75	409.17	477.74	54.50	1,984.20	655.00	
872.84		589.27		117.85	804.18	1,414.05	76.01	2,975.72	150.00	
786.65	221.08	2,209.46	59.94	2,792.41	12.50	1,510.14	537.92	1,836.82	2.00	47.33
2,198.44		4,705.52	30.79	1,611.33	859.69	5,208.94	185.96	842.60	208.97	1,057.75
326.78	50.61	431.64	154.82	605.16	539.37	633.64	31.50	5,367.53		
510.28		2,432.59	34.37	1,523.51	140.86	1,136.85	417.70	2,416.86		3,420.76
861.80	41.25	1,844.36	28.40	392.45	1,511.58	1,617.23	50.00	3,754.56	292.20	217.46
504.60	488.67	226.51	29.40	851.59	855.17	1,648.94	492.21	3,882.89	13.06	542.74
223.46		520.58	103.73	633.50	1,428.02	413.35		2,981.92	39.83	280.03
2,119.29	69.80	4,216.87	31.28	2,871.98	1,050.50	1,279.91	2,412.68	3,817.82	6.25	754.19
236.08	.71	394.23	34.10	278.34	625.02	900.00		2,124.79	554.86	
						941.94				
356.39	335.46	4,520.49		363.66		601.45	713.77	5,336.26	1.58	594.00
136.35		637.00	10.51	72.80	74.97	855.94		2,976.61		
672.12	9.75	4,970.71	47.63	10.32		1,269.91		57.32		
638.59		2,929.40		960.23	493.60	1,723.88	1,800.00	3,394.08		70.58
2,032.47	3.68		8.00	941.85	616.92	1,467.24	229.00	3,010.36	425.32	15.00
215.93	35.58	627.31		1,201.01	846.89	2,261.07	100.00	5,193.52	10.00	392.72
757.90	461.30	2,194.23	201.18	1,343.14	341.07	111.07	205.50	725.56		2,511.92
825.90	100.00	1,758.94		1,566.38	1,762.46	653.00	4.00	3,027.92		12.57
605.74		808.34	40.88	1,020.35	3,551.79	2,192.55	135.50	2,809.87		194.53
417.32	9.45		257.72	199.58	716.58	942.61		1,868.88		3,824.68
479.85		550.09	23.50	6.85	1,296.73	5,192.58		2,114.77	191.66	482.84
1,316.60		80.00	52.70	468.82	424.69	264.58	964.50	5,454.97		1,177.12
183.80	6.73	1,578.97	23.70	655.75	2,159.26	433.80		2,265.39	19.10	4,280.59
72.03	2.25	35.90	291.38	239.55	1,426.91	1,275.80		4,223.40		691.81
1,038.89		33.66	15.05	938.25	720.00	277.27	79.20	2,614.78		114.90
400.98		3,087.82		501.76	230.47	1,722.53	294.20	3,228.68	16.80	45.00
627.68	7.40	215.55	9.65	823.02	112.59	1,138.99	249.90	2,656.57	1.25	135.84
295.23		1,838.60	10.50	1,102.11	520.36	884.54	215.50	4,327.99	9.05	
29,095.56	3,985.11	57,974.80	3,297.37	36,461.78	41,556.46	67,633.26	15,086.34	145,445.23	3,653.69	31,200.29

TABLE 8.—Disbursements from the United States Treasury to the States and Territories for agricultural experiment stations under the acts of Congress approved March 2, 1887, March 16, 1906, and February 24, 1925

State or Territory	Hatch Act		Adams Act		Purnell Act	
	1888-1928	1929	1906-1928	1929	1926-1928	1929
Alabama.....	\$613,956.42	\$15,000	\$311,619.89	\$15,000	\$90,000.00	\$50,000
Arizona.....	579,803.10	15,000	314,955.61	15,000	90,000.00	50,000
Arkansas.....	613,139.12	15,000	314,900.00	15,000	90,000.00	50,000
California.....	615,000.00	15,000	314,926.84	15,000	90,000.00	50,000
Colorado.....	614,718.82	15,000	313,638.93	15,000	90,000.00	50,000
Connecticut.....	615,000.00	15,000	315,000.00	15,000	90,000.00	50,000
Dakota Territory.....	56,250.00					
Delaware.....	613,382.87	15,000	310,475.12	15,000	89,295.10	50,000
Florida.....	614,966.04	15,000	314,996.06	15,000	86,523.74	50,000
Georgia.....	610,593.43	15,000	302,092.87	15,000	90,000.00	50,000
Idaho.....	539,324.13	15,000	310,842.22	15,000	90,000.00	50,000
Illinois.....	614,564.95	15,000	314,851.62	15,000	90,000.00	50,000
Indiana.....	614,901.19	15,000	315,000.00	15,000	90,000.00	50,000
Iowa.....	615,000.00	15,000	315,000.00	15,000	87,965.17	50,000
Kansas.....	614,995.00	15,000	315,000.00	15,000	90,000.00	50,000
Kentucky.....	614,996.56	15,000	315,000.00	15,000	90,000.00	50,000
Louisiana.....	615,000.00	15,000	315,000.00	15,000	90,000.00	50,000
Maine.....	614,999.62	15,000	315,000.00	15,000	90,000.00	50,000
Maryland.....	614,967.40	15,000	314,236.48	15,000	90,000.00	50,000
Massachusetts.....	614,617.70	15,000	315,000.00	15,000	90,000.00	50,000
Michigan.....	614,676.10	15,000	311,341.20	15,000	90,000.00	50,000
Minnesota.....	614,917.78	15,000	314,345.00	15,000	90,000.00	50,000
Mississippi.....	615,000.00	15,000	315,000.00	15,000	90,000.00	50,000
Missouri.....	610,097.24	15,000	314,999.90	15,000	90,000.00	50,000
Montana.....	525,000.00	15,000	312,417.04	15,000	90,000.00	50,000
Nebraska.....	614,932.16	15,000	315,000.00	15,000	90,000.00	50,000
Nevada.....	614,214.32	15,000	313,180.28	15,000	90,000.00	50,000
New Hampshire.....	615,000.00	15,000	315,000.00	15,000	90,000.00	50,000
New Jersey.....	614,949.97	15,000	314,392.06	15,000	90,000.00	50,000
New Mexico.....	579,509.05	15,000	315,000.00	15,000	90,000.00	50,000
New York.....	614,757.18	15,000	314,463.01	15,000	90,000.00	50,000
North Carolina.....	615,000.00	15,000	300,000.00	15,000	90,000.00	50,000
North Dakota.....	556,502.26	15,000	314,638.85	15,000	90,000.00	50,000
Ohio.....	615,000.00	15,000	313,514.02	15,000	90,000.00	50,000
Oklahoma.....	539,002.16	15,000	294,535.19	15,000	90,000.00	50,000
Oregon.....	600,156.64	15,000	310,000.00	15,000	90,000.00	50,000
Pennsylvania.....	614,967.43	15,000	314,995.41	15,000	90,000.00	50,000
Rhode Island.....	615,000.00	15,000	309,520.20	15,000	90,000.00	50,000
South Carolina.....	614,542.15	15,000	313,460.12	15,000	90,000.00	50,000
South Dakota.....	558,250.00	15,000	310,000.00	15,000	90,000.00	50,000
Tennessee.....	615,000.00	15,000	315,000.00	15,000	90,000.00	50,000
Texas.....	615,000.00	15,000	312,592.26	15,000	90,000.00	50,000
Utah.....	480,000.00	15,000	314,821.94	15,000	90,000.00	50,000
Vermont.....	615,000.00	15,000	315,000.00	15,000	90,000.00	50,000
Virginia.....	612,824.12	15,000	314,949.01	15,000	90,000.00	50,000
Washington.....	552,102.65	15,000	311,080.11	15,000	90,000.00	50,000
West Virginia.....	614,968.71	15,000	312,859.12	15,000	90,000.00	50,000
Wisconsin.....	615,000.00	15,000	315,000.00	15,000	90,000.00	50,000
Wyoming.....	600,000.00	15,000	315,000.00	15,000	90,000.00	50,000
Total.....	\$28,901,546.27	\$720,000	\$15,019,640.36	\$720,000	\$4,313,784.01	\$2,400,000

ADDRESS LIST OF STATE AND INSULAR AGRICULTURAL EXPERIMENT STATIONS

- ALABAMA.—*Auburn*, M. J. Funchess, Director.
 ALASKA.—*Sitka*, H. W. Alberts, Director.
 ARIZONA.—*Tucson*, E. D. Ball, Director.
 ARKANSAS.—*Fayetteville*, Dan T. Gray, Director.
 CALIFORNIA.—*Berkeley*, C. B. Hutchison, Director.
 COLORADO.—*Fort Collins*, C. P. Gillette, Director.
 CONNECTICUT.—*New Haven*, W. L. Slate, Director; *Storrs*, W. L. Slate, Director.
 DELAWARE.—*Newark*, C. A. McCue, Director.
 FLORIDA.—*Gainesville*, Wilmon Newell, Director.
 GEORGIA.—*Experiment*, H. P. Stuckey, Director.
 GUAM.—*Guam*, C. W. Edwards, Director.
 HAWAII.—*Honolulu*, J. M. Westgate, Director.
 IDAHO.—*Moscow*, E. J. Iddings, Director.
 ILLINOIS.—*Urbana*, H. W. Mumford, Director.
 INDIANA.—*La Fayette*, J. H. Skinner, Director.
 IOWA.—*Ames*, C. F. Curtiss, Director.
 KANSAS.—*Manhattan*, L. E. Call, Director.
 KENTUCKY.—*Lexington*, T. P. Cooper, Director.
 LOUISIANA.—*Baton Rouge*, C. T. Dowell, Director.
 MAINE.—*Orono*, W. J. Morse, Director.
 MARYLAND.—*College Park*, H. J. Patterson, Director.
 MASSACHUSETTS.—*Amherst*, F. J. Sievers, Director.
 MICHIGAN.—*East Lansing*, V. R. Gardner, Director.
 MINNESOTA.—*University Farm, St. Paul*, W. C. Coffey, Director.
 MISSISSIPPI.—*A. and M. College*, W. R. Perkins, Director.
 MISSOURI.—*Columbia*, F. B. Mumford, Director.
 MONTANA.—*Bozeman*, F. B. Linfield, Director.
 NEBRASKA.—*Lincoln*, W. W. Burr, Director.
 NEVADA.—*Reno*, S. B. Doten, Director.
 NEW HAMPSHIRE.—*Durham*, J. C. Kendall, Director.
 NEW JERSEY.—*New Brunswick*, J. G. Lipman, Director.
 NEW MEXICO.—*State College*, Fabian Garcia, Director.
 NEW YORK.—*Geneva* (State Station), U. P. Hedrick, Director; *Ithaca* (Cornell Station), A. R. Mann, Director.
 NORTH CAROLINA.—*State College Station, Raleigh*, R. Y. Winters, Director.
 NORTH DAKOTA.—*State College Station, Fargo*, P. F. Trowbridge, Director.
 OHIO.—*Wooster*, C. G. Williams, Director.
 OKLAHOMA.—*Stillwater*, C. P. Blackwell, Director.
 OREGON.—*Corvallis*, J. T. Jardine, Director.
 PENNSYLVANIA.—*State College*, R. L. Watts, Director.
 PORTO RICO.—*Mayaguez*, G. F. Freeman, Director.
 RHODE ISLAND.—*Kingston*, B. E. Gilbert, Director.
 SOUTH CAROLINA.—*Clemson College*, H. W. Barre, Director.
 SOUTH DAKOTA.—*Brookings*, J. W. Wilson, Director.
 TENNESSEE.—*Knoxville*, C. A. Mooers, Director.
 TEXAS.—*College Station*, A. B. Conner, Director.
 UTAH.—*Logan*, P. V. Cardon, Director.
 VERMONT.—*Burlington*, J. L. Hills, Director.
 VIRGINIA.—*Blacksburg*, A. W. Drinkard, jr., Director.
 VIRGIN ISLANDS, U. S. A.—*St. Croix*, J. B. Thompson, Director.
 WASHINGTON.—*Pullman*, E. C. Johnson, Director.
 WEST VIRGINIA.—*Morgantown*, F. D. Fromme, Director.
 WISCONSIN.—*Madison*, H. L. Russell, Director.
 WYOMING.—*Laramie*, J. A. Hill, Director.

